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RENTS AND PRICES OF AGRICULTURAL LAND IN SOUTH WALES, 1915—1925.

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Until recent years farmers have paid little attention to the price of land and its influence on their economic position. While the great majority were tenants, and many were tenants on large estates held by single families for many years if not for generations, the rentals rather than prices of land were chiefly considered. Farmers might be interested in prices of farms as indicative of general economic or social conditions or as showing trends of economic or social organisation, but they were only indirectly affected by prices which were realisable. On some occasions the consideration of rental value by owners was affected by prices paid or obtainable, but on the whole the actual rents were determined more by the influences working on farmers' profits than on the broader and more complex influences which were affecting the price of land. The extent to which this position has changed in Wales is shown by the increase in ownership occupation.

Some surprising results are shown, for apparently occupying ownership has decreased in Anglesey and, very slightly, in Merioneth. The largest increases are found in Denbigh, Flint and Montgomery in the North, and in Monmouth, Brecon, Radnor and Pembroke in the South of the Principality. The general increase in occupying ownership here shown is not as great as many farmers would expect and the general disturbance of the feeling of security in the tenancy of farms has been very much greater than would be warranted by any change which is indicated in these figures. The number of sales has exceeded the increase in occupying ownership, and probably the increase in the frequency of sales has also been much greater though this cannot be

measured with any certainty. Much selling to purchasers other than occupiers or to other persons who desired to own for farming

Proportion of Agricultural Holdings owned by Occupiers.
(Per cent. of Total Acreage and Number of Holdings.[1])

County.	1913.		1921.		1922.	
	Acreage %	*Number* %	*Acreage* %	*Number* %	*Acreage* %	*Number* %
Anglesey ...	16·19	14·42	15·47	11·87	12·38	8·62
Brecon ...	9·60	8·10	17·43	11·22	16·53	13·12
Cardigan ...	12·36	13·70	18·78	17·80	15·18	14·47
Carmarthen ...	10·98	10·84	16·90	11·52	13·17	12·51
Caernarvon ...	8·21	7·48	10·09	8·61	8·37	7·60
Denbigh ...	8·55	7·70	14·62	12·51	12·81	10·12
Flint ...	7·85	8·14	17·58	15·19	15·53	14·05
Glamorgan ...	4·50	4·86	7·44	8·16	6·15	6·53
Merioneth ...	7·76	8·53	9·10	8·39	7·64	7·87
Montgomery ...	7·92	8·26	17·01	11·96	16·86	13·74
Pembroke ...	11·97	10·10	20·05	15·91	17·91	14·97
Radnor ...	10·68	11·23	14·94	15·63	15·77	11·27
Wales ...	*9·76*	*9·52*	*15·41*	*13·25*	*15·49*	*11·53*
Monmouth ...	9·02	10·28	15·81	15·7	14·69	11·01

[1] See Part I of the *Agricultural Statistics*, 1913, 1921 and 1922.

purposes has undoubtedly tended to increase the feeling of uncertainty in the tenancy of farms. But farmers have not always been opposed to the selling of farms or to the break-up of estates, and to some extent they welcomed opportunities of purchasing, especially under reasonable conditions. Whether from fear, or uncertainty, or from the desire to purchase land, farmers are now far more interested in the prices of agricultural holdings than they were a few years ago.

In view of the existence of this interest in changing conditions it seemed probable that a study of some of their economic effects might be useful. But an investigation of this character is fraught with many difficulties. Sales are made both publicly and privately, and in an old country the selling of land, with its many varied charges and obligations, is not a simple matter. Consequently much more time than was anticipated will be required for a complete collection and analysis of the available data. Nevertheless, the records for seven counties are in hand and a part of the analysis has been made. The results for these counties, though incomplete, will be at least interesting and of some value. Some records for other counties are in hand and when the collections for these counties are completed the economic analysis of the whole of the results will be pursued.

For the seven counties of Cardigan, Pembroke, Carmarthen, Brecon and Radnor, Glamorgan and Monmouth, records of sales of 1,330 agricultural holdings have been collected. The numbers for individual counties are shown in the Tables of analysis given later, but the following figures show the general nature of records.

Total Number of Sales Traced.

	Number.
With details.	
Small Holdings and Farms	717
Fields and Accommodation Land	206
Without full details.	
Small Holdings and Farms	275
Fields and Accommodation Land	132
Total	1,330

For the 407 cases in which full details were not obtained, the acreages and purchase prices only have been used for the statement of purchase price per acre. But even this item of information has been useful in the corroboration of other results. In the other cases, information on gross rental previous to sale, acreage and charges has usually been obtained, although in a few instances it is difficult to ascertain the nature and amount of charges with any certainty. But as only *gross* rents are here considered results are not affected by this uncertainty.

The general impression in South Wales, especially in south-west Wales is that sales of farms and agricultural land generally have been frequent and heavy, especially between 1918 and 1922, and that a very large increase in occupying ownership has occurred. This, however, is not entirely supported by the figures given in the *Agricultural Statistics* up to 1922.

Occupying Ownership of Agricultural Holdings in South Wales.

County.	*Acreage occupied by Owners.*			*Holdings owned or mainly owned by Occupiers.*		
	1913	1921	1922	1913	1921	1922
Brecon ...	19,130	31,129	29,784	262	381	341
Cardigan ...	32,018	45,501	37,573	887	1,111	888
Carmarthen ...	48,008	70,151	54,756	948	1,273	1,080
Glamorgan ...	11,752	16,958	14,167	269	409	319
Monmouth ...	21,316	34,833	31,898	476	680	587
Pembroke ...	36,697	58,296	52,158	592	367	865
Radnor ...	17,257	23,463	24,713	252	910	322
Total ...	186,238	280,331	245,049	3,686	5,131	4,402

The sales between 1915 and 1922 for which records have been obtained number over 1,200, but these are not necessarily records of purchase by occupiers; and evidently the turnover of agricul-

tural holdings has been very much greater than the increase in occupying ownership shown above. In some particulars these increases create a little impression of possible error. It is generally believed that a definite increase in occupying ownership has occurred in Cardiganshire, where there has certainly been a considerable sale of agricultural holdings. On the other hand, while a large increase in occupying ownership is shown in Brecon and Radnor the recorded sales have been relatively small. The figures for Pembrokeshire correspond more closely to expectations. Again the decrease in ownership between 1921 and 1922, which is marked both as regards acreage and numbers, is difficult to explain by any known general movement. Although there can be no adequate solution of the problem at the moment, it is probable that considerable numbers of agricultural holdings have been sold to investors other than those who desire to farm.

There were many reasons for sales of agricultural holdings, but the chief reasons for abnormal sales of the whole or portions of the larger agricultural estates were the desire to obtain a greater return on capital than that yielded by net rentals, the desire to escape heavy charges for repairs and improvements which had been postponed or evaded during the war years and earlier in some cases, and to a certain extent on a theory or a feeling that it was desirable to extend the ownership of land, especially occupying ownership. Conditions of land ownership or landlordism were variable in different parts of the Principality. In some large areas nearly all farms were members of large estates. In others estates were relatively small, containing only a few farms. While in still other areas there were large numbers of farms owned by individuals amongst the professional or merchant classes. And there have always been some farms other than the " home farms " of estates which were owned by their cultivators. It is extremely doubtful whether sales by occupying owners, or their families, or by the other types of persons who owned one, two or three farms have been very much greater than normal. The abnormal sales seem to have occurred largely on the " estates ", both large and small.

It is difficult to measure the degree of abnormality of sales of agricultural holdings, for the normal rate of selling is not known with any certainty. It is, however, known that considerable variations in the rate of sale or turnover of farms occurred even in " normal " periods. There were fluctuations in sales reflecting changes in general economic as well as agricultural conditions and special fluctuations like that of 1909-13, which was due partly to political and social fears, which would make it difficult to select

a " normal " period. Nevertheless it cannot be doubted that sales were unusually frequent in most areas from 1918 to 1922.

Whatever the reasons for selling may be there must be reasons for buying whenever sales occur. The seller and the buyer may have the same ultimate economic interests but they may read in different ways the economic signs or judge differently economic prospects; or the seller and the buyer may have different economic objects. And on the whole, the demand for agricultural holdings was equal to the offers during the periods considered, even though some farmer purchasers were activated by pressure rather than by personal desire to buy. In essentials the demand has not differed, except in degree, from that current in any other periods. Men have bought or fixed prices on the basis of economic interests —desire for security of capital, anticipation of increases in land values, desire for control or fear of loss of land for cultivation— and for sentimental or social reasons. The desire for control of land for farming purposes or fear of losing such control were probably the only reasons which were in any degree abnormally evident in the demand during the years under consideration.

The period 1915-1925 covers times of now slowly, now rapidly rising prices for agricultural produce; and then a time of rapidly falling prices, as is shown by the Index Numbers for prices of farm produce. But in large areas in South Wales where a lot of poor land is to be found the changes in prices of sheep probably had more influence on the demand for land than the changes in the general agricultural price level. The changes in prices of sheep can be indicated only for mutton or fat sheep, while great numbers of farmers in the area are far more interested in store than fat sheep. But it is evident that the high prices ruling for sheep during the years 1921-23 had a strong influence on the valuation of the poorer land.

Index of Prices.

	General Agricultural Produce.	*Fat Sheep.*
1911—13	100	100
1915	127	130
1916	160	157
1917	201	197
1918	232	210
1919	258	230
1920	292	287
1921	219	217
1922	169	200
1923	157	187
1924	161	187
1925	160	183

Changes in prices of fat sheep show variation from movements in prices of other products only during the years of "control", 1918 and 1919, and again after 1921. In the first period prices for mutton were relatively low, and in the later they were relatively high. But on the whole, prices for store sheep were highly satisfactory between 1916 and 1924. Costs of production on the sheep farms did not rise in close relation with general prices during those years, a satisfactory margin of profit was obtained in most seasons, and this caused a considerable demand for the poor land on which rents were low. This accounts for the comparatively high purchase prices paid for such farms.[2]

Considered as a problem of pure economics the valuation of land has been regarded merely as the capitalisation of the rent. "The capitalised value of land is the actuarial 'discounted' value of the net income which it is likely to afford", or "the method usually employed in the calculation for converting land income into land values (or prices) is to divide the annual income by the rate of discount or prevailing rate of interest, the income multiplied by the quotient being the value of the land". (If the net rent is £1 and the rate of interest 5%, then 100/5 = 20 : £1 × 20 = £20).

In a practical study, however, many complex factors have to be taken into account. The current rates of interest or "discount" are undoubtedly important, but in the determination of actual price many influences may enter. A rise or fall in the rate of interest may be anticipated. The actual gross rent of a particular farm payable at the time of purchase may be higher or lower than that which might confidently be expected under competitive conditions. There may be general expectation of a rise or fall in rents or rental values of all farms or of certain types of farms, which may affect the valuation of a particular holding. The general quality of the land, the limitation of its possible uses or its adaptability for several lines of agricultural production, through their influence on the risk in the maintenance of rent, may also be important.

Much of the land now under consideration has one chief use—some of it almost one sole use—that of production of store sheep, or sheep-raising with a little cattle-raising. Such land has

[2] It is also suggested that where there was fear of disturbance on sheep farms the occupiers were very anxious to remain and for special reasons agreed to pay high prices. The particular reasons suggested are (1) The strong attachment of this class of farmer to particular holdings; (2) The fact that on the farmer's removal from a holding the sheep remain, and that farmers were afraid of the high prices required and risks of buying flocks on other holdings. Custom as regards the second point varies by districts or estates.

few, if any, alternative uses. Much of the characteristic sheep land has very little present value for sporting purposes, and probably little potential value compared with conditions in Scotland. Some of it may have potential values for afforestation but has little present value for that purpose. Other and better land may be used for sheep-raising on a different system and sheep fattening with fairly good class cattle-raising. This land has greater possibilities of alternative use. On the still better land there are possibilities of such alternative uses as sheep-raising and fattening, cattle-raising or milk production. While on the best of the land there are possibilities of crop production, with the higher branches of live-stock production, down to the more primitive systems of animal husbandry if economic conditions require it. But quality of land here must not be taken as synonymous with fertility, for situation has a very important effect on the productivity of land in terms of cash values of the products. The risk of non-maintenance of rental values over long periods may vary inversely with the possibilities of alternative use of land. But the neglect of such risks under special conditions of profitableness of the particular industry on the poor land may easily be seen in the high rates at which poor land was valued during the boom in sheep prices. It could scarcely be doubted that such land would now be valued at much lower rates. But on the other hand, even some poor land from the agricultural point of view may have alternative uses outside the sphere of farming, and this appears to be particularly important in some parts of Wales.

The rate of years' purchase on land of varying potentialities and differing rentals may be seen clearly in the following figures. The *gross rent* per acre is shown because this is the indicator of farmers' estimates of relative productive value. The purchaser would doubtless think of *net rents* as the basis of capitalisation, especially if there were charges on the land. Net rents allowing for charges such as tithe, land tax, or other dues which may vary from farm to farm (but which have to be obtained from the produce of the farm for which they are payable), would not indicate so closely the relative agricultural values of different holdings.

The average years' purchase on *gross rent* of the whole of these holdings is just under twenty-six, but taking the *net rent* (gross rent less such charges as tithe and land tax) an average of between two and three years would be added to the years' purchase of all the farms subject to charges. For a few individual farms, the years' purchase on net rent would be increased by

four or five years, but over the whole group of 717 farms the years' purchase on net rent would be increased by only a few months. Twenty-six years is a fairly high rate of capitalisation,

Influence of Rentals on Years' Purchase in South Wales, 1915—1925.

Gross Rent per acre.	*Number of Holdings.*	*Mean of Gross Rent per acre.**	*Years' Purchase.**
Shillings.		s. d.	
Under 5	49	2 5	25·8
5—10	106	7 10	29·4
10—15	138	12 6	29·1
15—20	122	17 6	28·6
20—25	100	22 0	27·2
25—30	64	27 2	27·3
30—40	51	34 6	25·6
40—60	50	48 6	25·8
Over 60	37	87 5	24·8

* Rents and years' purchase here have necessarily been averaged from the figures for individual cases without allowing for the effect of varying acreages.

but the relatively high capitalisation of the values of the poorest land is remarkable. Twenty years' purchase or less might have been expected on land of a rental value of 2s. 6d. an acre, with little or no sporting values, for a heavy decline in demand for sheep and in prices would reduce its value and might put a good deal of it out of use for a time. But this risk was discounted by reason of experience of high profits on sheep farming and high hopes of its continuance for a short time. Probably some of the earlier purchasers of sheepwalks covered their expenditure on land, plus current expenses of production, by sales of sheep during the boom years.

More remarkable are the high rates of capitalisation of values on the relatively poor land at rentals of 5s. to 20s. per acre. There is a strong probability that this was partly due to existence of rentals below what were possible under competitive conditions, but it is also due to the fact that many of these farms are relatively small and the small farm at a low rental offers possibilities of purchase to a large group of persons. As will be shown later, the smaller farms command the higher purchase rates, and with low rentals, whether in fact or in potentiality, strong competition arose.

On the other hand, the actual gross rentals at the higher levels were nearer to the real level of competitive rent even if some of them were not excessive. In some cases, all the agricultural values, actual and potential, as well as others such as prospective site values, had already been taken into account in

the fixing of rents. In all cases of very high rents practically all the agricultural values seem to have been anticipated in the rents, but in some cases building values not covered by rents remained to be capitalised in price. Moreover, as far as farmers are concerned, the possible purchasers of highly rented farms are comparatively scarce.

But these results should be studied most carefully in the chart of frequency distribution of years' purchase on the gross rental basis (p. 28). At rentals between 70s. and 120s. per acre there is only one case exceeding thirty years' purchase. At rentals over 120s , where values are mainly determined by situation or by prospects of building, the years' purchase tends to rise. Between 50s. and 70s. there is no instance of more than thirty-five years' purchase, but on lower levels the " scatter " is remarkable. Some high rates of purchase are due to rents which were too low, while low rates of purchase are almost solely due to rents which were too high; but many high rates of purchase at the lower rentals are due to sentimental values attached to farms by their occupiers. There is probably also much more of prospective building value on some of the poor land than might have been expected.

As regards building values in general, it must be remembered that all these are cases of farms. Bare land is treated separately and results are shown in later tabular statements. No known cases of existence of mineral values or prospects of minerals which would have a definite effect on valuation are included. These sales have occurred over a period of eleven years, yet although the records include prices realised in what was supposed to be a " boom " period (1918-21) these prices do not invalidate results. The number of years' purchase of farms are only a little higher in 1919-22 than in other periods and for some types there is little if any difference. The general concentration of cases between the twenty and thirty years' purchase points corresponds

Rental. Shillings.	*Total Cases.*	*Cases within + and — ¼ average.*	*Per cent. of total.*
0— 5	49	38	77·5
5—10	106	75	71·0
10—15	138	103	74·6
15—20	122	89	73·0
20—25	100	74	74·0
25—30	64	41	64·0
30—40	51	33	66·0
40—60	50	31	62·0
Over 60	37	21	57·0

to expectation, but on no ground of theory yet discovered would so much " scatter " have been anticipated. Perhaps the scatter is most simply indicated by showing for each group the number of cases which fall within figures representing plus or minus one-fourth of the average for each group.

Thus at all rentals except the lowest more than one quarter of all the cases scatter very widely from the average of years' purchase for the group.

Indeed, if this group of results is at all representative it shows that actual valuation of farms is strongly affected by considerations other than those of rates of discount, existing rents, and risk of income and that it cannot be reduced to any formula. It has recently been suggested that the valuation of agricultural land may be " a mere matter of arithmetic in the great majority of cases "; and that when the net income from such land is known " the only question for consideration is the number of years' purchase at which (the income) should be capitalised and this would depend upon the value of money at the time of the transaction ".[3] As regards the suggestion of principle it may easily be seen that for this group of farms it has no general applicability.[4]

It is further suggested that in 1925 " twenty-two and a half years' purchase of the Schedule A assessment would represent, presumably, something about the purchase price ". Clearly, when the purchasers of the farms dealt with above have paid an average of nearly *twenty-six years' purchase on gross rent* and a little more than twenty-six years' purchase on net

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[3] Orwin and Peel: *The Tenure of Agricultural Land*, pp. 44-45. Readers should see the whole section, " Present Proposals ".

[4] The average Bank Rate (minimum rate per cent. of discount charged by the Bank of England) has varied as follows:—

	%		%	
1913 ...	4·77	1919 ...	5·15	
1914 ...	4·03	1920 ...	6·71	
1915 ...	5·00	1921 ...	6·09	
1916 ...	5·47	1922 ...	3·69	
1917 ...	5·15	1923 ...	3·49	
1918 ...	5·00	1924 ...	4·00	
		1925 ...	4·5	(Approx.)

But actual rates have shown variation between 3 and 7 per cent. There is very little, if any, reflection of changes in the Bank Rate or of other interest rates in the years' purchase fixed in the sales recorded. Rates which exist only for a short period exercise little influence on the purchase of land, and it is the net result of changes in the average rate obtainable over fairly long periods, rather than particular rates existing for short periods, which in practice are taken into account in the valuation of land for purchase. But even the average rate obtainable or expected will not determine the value of individual farms or of holdings of some particular types. The values of small holdings, especially, are less subject to the influence of the prevailing rate of interest than those of other types of farms.

rent and at none of the periods have they paid on the average less than twenty-three and a half years' purchase for their farms considerable injustice might be done if the State or any other purchaser were enabled to take the land at twenty-two and a half years' purchase on net rent. But when individual cases, even of real economic values, are considered it will easily be seen that grave errors would be committed in any valuation of farms as a mere process of arithmetic.

It is impossible to deal with all the "agricultural" factors in the determination of values of farms in the space available, but these will be considered on a further analysis of the data. It is, however, necessary to deal with certain differences arising from locality and size of farm, with time of sale.

As regards accommodation land and fields, always without farmsteads and generally without any buildings, the results may be stated in simple form. There are altogether 338 cases, of an average size of 14.2 acres, showing an average price of £50/8/- an acre. The differences between the group for which complete details are available and that for which only acreage and price could be obtained are very small.

Accommodation Land and Fields.

	Group with details.	*Other Group.*
No. of cases ...	206	132
Total acreage ...	2966·6	1834
Average area ...	14·4	13·9
Total gross rent ...	£5,235 12 0	—
Rent per acre ...	1 15 3	—
Total purchase price ...	£146,222	£95,818
Average purchase price per acre ...	£49 4 0	£52 4 3
Years' purchase on gross rental ...	27·9	—

Rents of accommodation land and separate fields prove to have been relatively high, but most of the future values appear to have been discounted in the rents. The number of years' purchase is not greater than is found for some classes of farms, although it exceeds by two years the average of all farms.

In arriving at the value of farms and small holdings the value of timber has been deducted whenever timber of particular value, as is generally the case, has been valued before sale. Gross rents only are here dealt with, but apart from this the prices and years' purchase represent the agricultural values, except where farms or parts of them had prospective building values. And in these days, when towns and industrial areas are spreading widely,

and when a good deal of land which is not in the immediate vicinity of towns has some present or prospective residential value because of the attractions of various types of situation, it is extremely difficult to segregate agricultural and building values in the prices of farms.

It appears, therefore, that the group for which details have been obtained are fairly representative of the whole of the sales of this type of land. The following table shows the details by areas.

Sales of Accommodation Land and Fields, 1915—1925.

County.	*Number*	*Average area.*	*Average Gross Rent per acre.*	*Purchase price per acre.*	*Years' Purchase on Gross Rent.*
		acres.	£ s. d.	£ s. d.	
Pembroke ...	49	7·13	2 0 2	60 10 0	30·8
Cardigan ...	31	19·14	0 15 6	26 0 6	33·8
Monmouth and Glamorgan	95	18·09	2 1 3	55 0 10	26·5
Brecon, Radnor and Carmarthen	31	9·96	1 13 6	48 15 6	29·4
All cases.					
1915-18 ...	101	19·3	1 16 7	46 6 0	25·3
1919-22 ...	97	9·2	1 14 10	59 2 0	39·8
1923-25 ...	8	14·6	0 16 7	23 10 0	26·8
South Wales 1915-1925 ...	206	14·4	1 15 3	49 4 0	27·9

For the whole of the sales of farms and small holdings the items dealt with are :—

	Farms with details.	*Farms lacking details.*	*Total.*
No. of cases ...	717	275	992
Total acreage ...	82,047	39,995	121,992
Average area ...	114·4	145·25	122·9
Gross Rent ...	£52,268	—	—
Average rent per acre ...	12s. 9d.	—	—
Total purchase price ...	£1,350,386	£1,055,694	£2,406,080
Average purchase price per acre ...	£16 8 0	£26 8 6	£19 14 0
Years' purchase on gross rental ...	25·8	—	—

On the whole the farms for which details were unobtainable were slightly larger and better than those for which the details

were to be had, and the purchase price per acre was certainly higher.[5]

The chief determinants of value to be considered now are locality, size of farm, with period of sale. Taking first the situation, by counties, the results for all farms are given below. Many more details of analysis are available but cannot be presented here.

Sales of Farms: By Groups.

Period and Area.	*No. of Cases.*	*Mean Area.*	*Mean Rent.*	*Purchase Price per acre.*	*Years' Purchase on Gross Rent.* *Number*	*Normal Range.*	
I. Under 50 Acres.							
		Acres.	s. d.	£			to
1915–18.							
Pembroke	11	31.8	36 0	38.8	21.5	18	29
Cardigan	27	26.4	18 0	24.0	25.5	18	40
Glamorgan and Monmouth	56	22.4	37 2	46.1	24.8	15	30
Carmarthen, Radnor and Brecon	23	29.1	24 8	25.9	21.3	20	33
1919-22							
Pembroke	45	7.1	40 6	61.6	31.2	24	44
Cardigan	32	23.6	19 8	33.1	33.8	21	45
Glamorgan and Monmouth	42	18.7	36 7	69.5	38.0	20	45
Carmarthen, Radnor and Brecon	34	29.5	19 6	29.0	29.5	19	41
1922-25							
Pembroke	4	7.8	43 7	60.9	27.9	23	28
Cardigan	8	18.9	18 4	23.5	25.6	22	28
II. 50 to 150 Acres.							
1915-18.							
Pembroke	10	103.7	18 3	23.2	25.3	21	28
Cardigan	39	95.9	11 5	15.0	26.3	22	37
Glamorgan and Monmouth	21	97.5	22 0	30.9	28.0	21	39
Carmarthen, Radnor and Brecon	19	103.9	20 4	25.2	24.7	19	29
1919-22.							
Pembroke	19	89.1	19 6	25.4	26.4	20	35
Cardigan	44	96.2	13 2	17.9	27.0	21	36
Glamorgan and Monmouth	42	95.4	19 1	24.4	25.6	19	36
Carmarthen, Radnor and Brecon	30	86.3	11 10	16.8	28.3	19	37
1923-25.							
Pembroke	4	110.0	25 5	23.1	18.2	17	19
Cardigan	13	80.0	11 6	15.6	26.7	20	29
III. Over 150 Acres.							
1915-18.							
Pembroke	5	233.0	13 1	15.2	23.2	20	28
Cardigan	32	407.3	3 5	4.3	24.8	20	33
Glamorgan and Monmouth	13	414.1	10 10	13.6	25.1	20	31
Carmarthen, Radnor and Brecon	8	397.5	8 8	9.7	22.6	18	27
1919-22							
Pembroke	20	251.9	18 9	22.5	23.8	21	30
Cardigan	22	331.5	4 4	6.1	28.1	20	31
Glamorgan and Monmouth	25	248.1	16 8	21.3	25.5	20	35
Carmarthen, Brecon and Radnor	13	209.9	13 2	13.4	20.3	15	32
1923-25.							
Cardigan	9	598.3	3 5	4.1	23.8	21	27

[5] It is unfortunate that this group of the better farms cannot be more fully dealt with at the present time, but information as regards the sales of some of these farms will be further pursued.

The most striking result of this table is the indication of the extraordinary individuality of the capital values of farms even when they are grouped by size. This is shown both in price per acre and years' purchase. The normal range of years' purchase for each group shows the points between which the majority of cases are to be found, but many individual cases fall under or above the points shown. The widest range, the greatest individuality of capital values, is seen to occur amongst small holdings. The largest farms, on the whole, show least range of years' purchase. The large range in years' purchase of small holdings is probably due to greater variation of actual rents from fair competitive rentals in this group than in others. These holdings naturally show the highest rents and the highest purchase prices per acre, but this is due partly to the relative disproportion of values of buildings to values of land on this class of holding.

But the size of holding seems to be the most important single factor in determination of the variations in values, for in general rents, purchase price per acre, and years' purchase fall as the size of holding increases. So far as reliance may be placed on the evidence of these sales the size of holding is far more important in the determination of rate of years' purchase than either general situation or period of sale. Over a period of eleven years, with

Average Results of Sales by Size of Holding.

Size and County.	*No. of Cases.*	*Average area.*	*Average Rent per acre.*	*Average Purchase Price per acre.*	*Years' Purchase on Gross Rent.*
1—50 ACRES.		acres.	s. d.	£	Number.
Pembroke ...	77	23·7	29 4	38·4	26·1
Cardigan ...	67	23·9	16 8	28·2	29·5
Glamorgan and Monmouth	98	20·8	36 11	55·1	29·8
Carmarthen, Brecon & Radnor	57	29·3	21 7	27·7	25·7
Average	*299*	*23·9*	*27 5*	*37·0*	*28·0*
50—150 ACRES.					
Pembroke ...	63	92·7	19 9	24·9	25·8
Cardigan ...	96	93·9	12 3	16·4	26·8
Glamorgan and Monmouth	63	96·2	20 1	26·6	26·6
Carmarthen, Brecon & Radnor	49	93·2	15 6	20·4	26·3
Average ...	*271*	*94·0*	*16 5*	*21·5*	*26·2*
OVER 150 ACRES.					
Pembroke ...	25	248·1	17 8	21·1	23·7
Cardigan ...	63	408·1	8 8	4·7	25·7
Glamorgan and Monmouth	38	304·9	13 11	17·7	25·8
Carmarthen, Brecon & Radnor	21	281·4	10 8	11·4	21·3
Average ...	*147*	*336·1*	*8 8*	*10·6*	*24·4*

a very varying rate of interest, the small, medium and large farms show respectively 28, 26 and 24½ years' purchase. In the group of large farms the average rent is very much reduced by the extremely low rents of the holdings, including a number of sheep-walks, in Cardigan. But these are typical of the areas and cannot be excluded. The average years' purchase, however, is raised rather than lowered by the inclusion of these holdings.

Taking the results by areas, the lowest rental values and purchase prices per acre are found in Cardiganshire, but competition for the relatively poor land in this county has been keen and high rates of years' purchase have been realised. This result is the more remarkable as Cardigan shows the group of largest holdings, but the prosperity of the sheep trade helped to maintain a high purchase rate in the county. Pembrokeshire, with the highest rents and purchase prices per acre, shows a little less than the average years' purchase. But the highest rate of purchase is shown for Glamorgan and Monmouth, where the high purchase

Average Result of Sales by Areas.

County and size.	*No. of Cases.*	*Average area.*	*Average Rent per acre*	*Average Purchase Price per acre.*	*Years' Purchase on Gross Rent.*
Pembroke.		acres.	s. d.	£	Number.
1—50 ...	77	23·7	29 4	38·4	26·1
50—150 ...	63	92·7	19 9	24·9	25·3
Over 150 ...	25	248·1	17 8	21·1	23·7
Average ...	*165*	*84·0*	*20 1*	*25·0*	*25·0*
Cardigan.					
1—50 ...	67	23·9	16 8	28·2	29·5
50—150 ...	96	93·9	12 3	16·4	26·8
Over 150 ...	63	408·1	3 8	4·7	25·7
Average ...	*226*	*160·7*	*6 6*	*8·6*	*26·7*
Glamorgan and Monmouth.					
1—50 ...	98	20·8	36 11	55·1	29·8
50—150 ...	63	96·2	20 1	26·6	26·5
Over 150 ...	38	304·9	13 11	17·7	25·3
Average ...	*199*	*99·8*	*18 2*	*24·3*	*27·2*
Carmarthen, Brecon & Radnor.					
1—50 ...	57	29·3	21 7	27·7	25·7
50—150 ...	49	93·2	15 6	20·4	26·3
Over 150 ...	21	281·4	10 8	11·4	21·3
Average ...	*127*	*95·6*	*14 1*	*17·1*	*24·3*

rate for small holdings which are comparatively highly rented is remarkable. Competition seems to have been least keen in the area of Carmarthen, Brecon and Radnor. Carmarthen is a typical small-farming county in which competition for small holdings

might have been expected to be keen, while the others have slightly larger farms. But there has been less disturbance over the whole of this area than in others, and this has probably tended to weaken competition for the farms which were on offer.

The period of sale appears to have had very much less influence on the rate of years' purchase than might have been expected. The highest prices and years' purchase, on the average, were obtained in the years 1919-22, but as regards the rate of capitalisation the difference between this and the earlier period is not marked. There are, of course, complications of size holding, and quality of land on offer in different periods, to say nothing of many other complications which may arise, but even in the result shown below it is probable that the size of the holding is of greater importance than the period of sale. In any case, it should be noted that in the summary by periods both the price per acre and years' purchase vary inversely with the size of holding, and that the small holdings show the greatest difference between prices and rates in the boom period and the others. Indeed, the other groups show practically no difference between the rates of capitalisation in the period 1915-18 and of 1919-22. As regards the latest period, the scarcity of cases makes it dangerous to draw conclusions. But the summary indicates quite clearly the heavy selling at the end of the war and explains the disturbance and the fears then felt.

Average Results of Sales by Periods.

All Farms.	*No. of Cases.*	*Average area.*	*Average Rent per acre.*	*Average Purchase Price per acre.*	*Years' Purchase on Gross Rent.*
		acres.	s. d.	£	
1915—18 ...	267	129·7	11 1	13·8	24·9
1919—22 ...	112	97·9	15 2	20·2	26·5
1923—25 ...	38	185·5	6 6	7·6	23·5
—50 acres.					
1915—18 ...	120	25·5	30 1	35·6	23·6
1919—22 ...	167	23·3	25 7	41·0	32·0
1923—25 ...	12	15·2	22 8	29·9	26·3
Average ...	*299*	*23·9*	*27 5*	*37·0*	*28·0*
—150 acres.					
1915—18 ...	89	98·9	16 9	21·9	26·3
1919—22 ...	165	92·1	16 0	21·6	26·5
1923—25 ...	17	87·2	15 8	17·8	22·7
Average ...	*271*	*94·0*	*16 5*	*21·5*	*26·2*
Over 150 acres.					
1915—18 ...	58	292·4	6 5	7·8	24·3
1919—22 ...	80	265·8	12 6	15·3	24·5
1923—25 ...	9	596·3	3 5	4·1	23·8
Average ...	*147*	*336·1*	*8 8*	*10·6*	*24·4*

The rents shown in the above Tables may appear to be on the low side, but some comparison with other rents is possible. The County Councils of Wales hired 8,470 acres between 1908 and 1918 at a total annual rental of £6,667 or 15s. 9d. an acre. This compares fairly favourably with the average rent of 12s. 9d. per acre for *all holdings* dealt with above, for on the whole the land hired by County Councils was of higher than average quality. The County Boroughs of Newport and Cardiff hired 215 acres of land at an average rent of £1 4s. 5d., which, as would be expected, is higher than the average rents shown for the counties of Glamorgan and Monmouth, but much lower than the rents of equipped small holdings in those counties.

In the seven counties for which figures have been given the County Councils hired nearly 7,000 acres of land at a rent of about 14s. per acre,[6] which compares very favourably with the average rent of farms shown. On the whole the rental values of the farms dealt with seem to be fairly representative of those prevailing in South Wales.

As regards purchase price the County Councils of Wales purchased nearly 18,000 acres of land at an average price of about £22.12 an acre. But in the seven counties of South Wales the Councils purchased 5,743 acres at an average price of £24 11s. 0d. These values are high in comparison with £16 8s. 0d. for the sales analysed or £19 11s. 0d. for the average of all the sales for which records have been obtained. But the land purchased by Councils was of higher than average quality, and much of it was more conveniently situated than the average of land which has been subject to sale. Consequently, somewhat higher prices are easily explainable. In view of all the figures obtainable it appears that the records dealt with are fairly representative and had details for the other farms been obtainable it is possible that the average years' purchase would have been slightly reduced.

A comparison of the theoretical value of land as a source of future income and the actual prices paid yields an interesting result.

Period.	*Average Bank Rate Approx.* %	*Theoretical Years' Purchase of land.*	*Actual Years' Purchase on Gross Rent.*
1915—18	5·15	19·4	21·9
1919—22	5·33	18·7	26·5
1923—25	4·00	25·0	23·5
Whole period.	4·93	20·1	25·8

6 See *Land Settlement in England and Wales*, 1925, pp. 140-141.

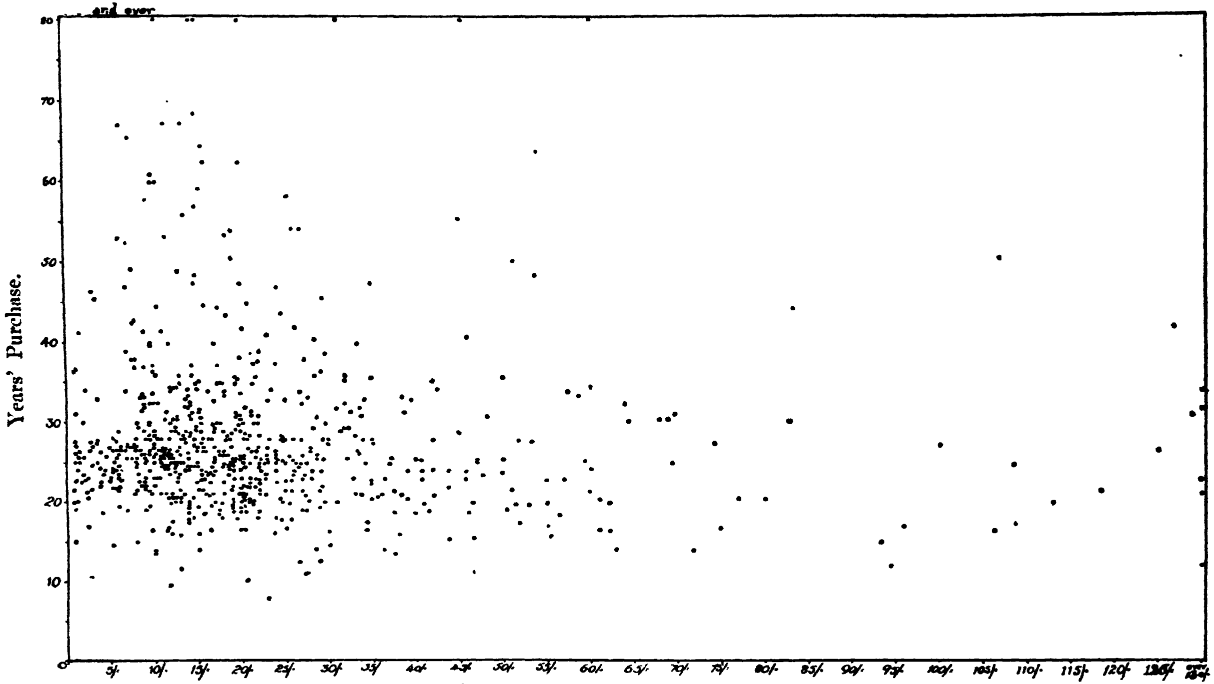
As stated previously, the actual determination of years' purchase is complicated by many factors, but this and the comparison of the discounted value of future income with the actual years' purchase only strengthens the conclusion that the simple arithmetical method of estimating values is a very unsafe one. Evidently the prosperity of farming and the expectation of future prosperity more than counteracted the influence of the high interest rates ruling at certain times. The interest rates represented by the *gross* rents in the three periods are approximately 4, 3.77, and 4.25 per cent. respectively. Over the whole of the farms the interest rate would be about 3.88, against the average Bank Rate of 4.93 per cent. But when charges on land payable out of rent and the necessary expenses of administration and maintenance of the properties are taken into account the net incomes would show considerably lower rates of interest.

Individual interest rates on farm mortgages and loans in Wales vary in an extraordinary way. There are known cases of 3½ and 5½ per cent. fixed within the last two years of the period dealt with, and there is talk of even wider differences, so it would be difficult to calculate an average rate of interest without compiling data for a mass of cases. The common idea of loan rates is that of one per cent. above Bank Rate. At this rate the average loss of interest to purchasers, calculated as the difference between gross rent as interest on purchase price and an interest rate of one per cent. above Bank Rate would be as shown below.

	Interest Rates. (Bank Interest plus 1%).	*Theoretical Years' purchase on Interest Rate.*	*Actual Years' Purchase.*	*Rent as interest on Price.*	*Difference between Rent and Interest Rate (—).*
	%			%	%
1915—18	6·15	16·3	24·9	4·02	2·13
1919—22	6·33	15·8	26·5	3·77	2·56
1923—25	5·00	20·0	23·5	4·25	0·75
Whole period	5·93	16·8	25·8	3·87	2·06

The results so far obtained show that unless values of land tend to rise in the future the farmers who have purchased in the last eleven years are in a less favourable financial position than those who remain as tenants. But from other agricultural points of view further analysis is required before the complete results can be obtained. The collection of records will be continued and a further analysis pursued if this is possible. Records for sales in North Wales are particularly required.

Frequency Distribution of Rents and Years' Purchase, South Wales Farms, 1915—1925.



Gross rent per acre per annum. Years' purchase exceeding 80 and rents exceeding 130/- per acre have been compressed to those points.

N.B.—" Net Rent " as used in this paper allows only for deduction of " charges " on land. The true net rent, i.e., net income, must also allow for repairs and other necessary expenditure.

SELLING LIVESTOCK IN WALES.

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It is strange that while livestock forms the most important part of the produce of Welsh farms the methods of marketing it have changed so little in the last half century; and, even though they are changing now, that the changes advance so slowly. Auction marts are unpopular in many parts of the country. Although many exist some are organised in a more or less haphazard fashion, and often fail to win farmers' confidence to the extent that it is gained by similar marts in some other parts of Great Britain. According to the *Linlithgow Report*, 1923, it was "difficult, particularly in some parts of the South and West of England, to induce farmers to dispose of their stock in any other way"[1] than through these marts. And, generally, "by far the greater part of the livestock ready for slaughter is sold by auction at local markets, to which the stock may be driven, carted, or railed by the farmer".[2] In "some parts of the country farmers own a large number of auction marts". This is quite different from conditions in Wales. There are auction marts owned by farmers, and there are many marts of this type run by private enterprise; yet it would be safe to say that the great majority of livestock of all types in Wales is sold by other less organised and more primitive agencies.

A recent survey of farm marketing in Breconshire has revealed the following systems of selling livestock.[3] Sale :—

To farmer (by farmer) on the farm.
To dealer—on the farm.
In weekly (or periodical) private treaty markets.
In seasonal (or special) fairs.
In auction marts established in open markets.
In auction marts privately owned and controlled.
In one auction controlled by organised farmers.
In dispersal sales, by auction, on the farm or nearby.

But "sale to a local dealer at home has been one of the chief means of disposal of livestock until recent years. In certain

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[1] *Interim Report on Meat, etc.*, p. 17.
[2] *Ibid.*
[3] *A Survey of Farm Marketing in Breconshire*, by H. J. Meredith, M.Sc., Agricultural Economics Department, University College of Wales—to be published. Quotations which follow are from the Report on this Survey.

districts despite the modern trend towards improved methods of marketing, sale to local dealers is still prevalent and can in many instances be termed the chief method of disposal ". " Auction marts were comparatively uncommon in Breconshire prior to the war, except for special sales of fat stock or of herds of cattle and flocks of sheep ".

As regards sheep from the mountain farms, " it is difficult to obtain exact numbers, but it is estimated that seventy-five per cent. of these are sold privately to farmers and dealers ". Only if the farmer fails to sell by these methods are they offered by auction, and " probably the most common method adopted by the mountain farmer is to sell his sheep at home to a private dealer ". On the lower " hill " farms, the same methods are adopted, except that fat sheep are frequently sold by weight, even when bought by the butchers or dealers on the farm. Near the industrial areas, in the south of the county, the store sheep " are sold at home on the farm or at the local fairs, to dealers who take them to other districts ". Generally over the county it may be said that " of the sheep sold privately more are sold at home than in the fairs ". In the case of wool, " the greater quantity is sold directly to wool merchants by private bargaining ".

Similar methods are followed in the sale of cattle. " Excluding the sale of calves and of cows with calves probably eighty to ninety per cent. of store cattle are sold by private treaty ", either on the farm or at the markets and special fairs, and " store cattle are never weighed before sale ". Sale of cows may take place on the farm or in the market by private treaty, or in an auction for store stock, but there " is probably less uniformity in the method by which a single farmer disposes of a number of cows over a series of years than in the methods of disposal of any other stock ". Fat cows are almost all sold by auction although only a few are weighed. Only a small proportion of the fat cattle are sold on the farms, probably owing to the difficulty the farmer experiences in estimating the value of a fat beast.

Amongst pigs, the weaners and stores are sold generally but not exclusively on the farms. They are frequently taken to the markets, where they are usually sold by private treaty. The fat porkers are sold either on the farm or at auction marts, according to the district. Some horses are sent to auction marts, many others are sold on the farm to dealers, while large numbers are on sale at the special horse fairs.

Such observations might be repeated in many parts of Wales. Fat lambs, especially the early ones, are usually sold on a live-weight or deadweight (or estimated deadweight) basis. This is

also the case with porkers in some of the most important pork feeding areas. Fat calves and bullocks are often weighed before being offered, but the weight is not necessarily stated at time of sale. In some special sales of fat stock, all animals are weighed and the weight declared at time of auction. But, taking the whole of Wales, and all classes of livestock, the greater part and probably the greatly predominating part is sold by private treaty on farms, in open (periodical) markets, and at special fairs. Thus it is sold with a minimum of publicity, with judgment entirely dependent on eye and hand, and, to say the least, on meagre information as to supplies and prices in other areas.

Many reasons are given for this, and amongst them long distances from markets, custom or the attachment of farmers to known methods or to persons, suspicion of new methods, attachment by credit, and the infrequency of marketing some stock, as, for instance, store sheep. Other reasons are given, by which a defence rather than an explanation of the prevailing systems is attempted, e.g., that other systems have been tried tentatively and been found unsatisfactory—that auction marts are controlled by rings, etc. But an opinion may be hazarded that the real reasons are not primarily of an economic character. The trading persons who form the other party in the markets are very strongly entrenched not only economically but by personal connections. Habits and customs exercise a great influence on farmers; suspicion and dread of innovation are very keen; and, most important of all, the farmers find in the personal selling of their stock the most interesting human task which comes to them in their business activities. As regards credit, attachments to dealers are not general nor are they very strong, except in a small minority of cases. Farmers who rarely buy stock and have little need of credit will wait a long time for the regular visit of a dealer to whom they are in the habit of selling, even at the risk of losing when demand is weakening and prices are falling.

It is common to regard marketing as a purely economic process governed by supply and demand, and a market as a piece of economic mechanism. Doubtless some marketing processes are based on knowledge, and the constant examination of experience leads to an approximation to rationality in their direction. Doubtless also some markets more or less mechanically register in prices changes in supply and demand. But it would be a great mistake to regard the live-stock markets of Wales as such. Their fundamental character is that of the meeting of human beings: of two individuals, as on the farm, and of groups of individuals in the open markets and fairs.

In the dry terms of the *Linlithgow Report*[4] " some are purely private treaty markets where stock is disposed of by negotiation direct to butchers or dealers ". Sale is made " by private treaty "; " the price is settled by negotiation ". Dealers are not deceived by such terms. They know that negotiation and treaty are human processes in which information, intuition, suggestion, character and personality play their parts. The most lamentable fact is that information plays a meagre and uncertain part.

Publicity is one of the essentials of a rational or efficient market, and the organisers of most markets which are intended to be of this character take steps to secure certain forms of it. In a perfect market both buyers and sellers would be equally well-informed of conditions in the present and the past. It could not then be entirely rational, for there would be scope for judgment of the future for which past experience would not be a sufficient guide and in which the temperaments and characters of individuals would play a large part. But in the live-stock markets of Wales the sellers have little reliable information even on present conditions. They try to read the past and thus to secure guidance for the future, but there is little methodical examination even of this. The buyers have a much greater and more reliable stock of information and the better class of buyer has, as a rule, as good information as is obtainable for the markets in which he trades.

The sources from which livestock sellers can obtain information are both few and poor. They are :—

Local newspapers.
National newspapers.
Conversation with neighbours.
" Feeling the market " or information gleaned in open markets.
Public auction sales.

The best information is that obtained in auction sales, provided they include stock of the type which the farmer has to sell; for there he can see the animals, hear the public statement of price, and watch the bidding. But this source of information is not by any means universally available in respect of some classes of stock, as for instance mountain ewes, and, in some districts, store sheep generally. Even store cattle in certain districts are little sold by auction. In other districts only the poor stock which cannot be sold privately is taken to the auction. On pigs there is little information to be gained through this channel; and

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4 *Interim Report on Meat, etc.*, p. 16.

as regards fat stock generally there is little to be gained except in a few areas.

"Feeling the market" is largely a process of judging the dealer's attitude when he arrives at the farm to buy; or of judging the reasons for the enquiries of other dealers than the one to whom stock is generally sold. Some farmers know when to expect a keen trade because enquiries are made before the stock is ready or before the normal date of sale. If demand is strong or prices are hardening the dealer tends to make his buying visit at an early period, but on the other hand when a depression is threatening the visit is often delayed. Thus does the dealer manipulate his buying market. In open markets where private treaty sales are conducted, the stock may be seen, the activities of buyers observed, and the degree of their keenness can be judged. But unless a seller who is considering selling stock in the near future has a friend or neighbour who is doing so at the time of observation it may be difficult to discover what prices are paid for individual animals or bunches of stock. The seller who is on the market offering stock, being under the necessity of standing by to receive offers, has very little opportunity of getting to know the actual prices which are passing. He frequently knows only the prices which different buyers offer to him. Then it is customary for one buyer to keep away until another has finished his chaffering with the seller, and frequently the second buyer finishes with the same offer as the first. The actual offers may be based partly on the value of the animals, but they may also represent the price for which the buyers judge one of them will eventually get the stock if they hold firmly to their offers. Thus it often happens that various prices are paid for animals of one type and quality offered in an open market on the same day. Indeed, the information of the farmer actually selling privately in the open market does not differ in character from that of the man selling on the farm; while it differs in amount it is sometimes not much greater. This is not to say that supply and demand, or competition, do not affect the open markets, for they obviously do in the differing degrees of activity of dealers under various circumstances, and sometimes in the activity of farmers who are buyers for their own purposes. But the fact remains that information even in the open markets tends to be on the one hand vague and general, the result of general observation; and, on the other, limited to certain isolated cases, as in the ascertainment of prices for the few bunches of stock for which information is personally obtainable.

Conversation with neighbours is very much of the same character. The conversations in the market lead to some pooling

of information and judgment as regards trade on that particular day or on recent days, but again information is local in character unless some of the conversants have attended other and relatively distant markets. The man who has not been to market can get the judgment of one or more neighbours after they return home. Occasionally there is a man in a locality who travels more, or reads more than his neighbours, whose information or judgment is shared with a few others. But where there are social classifications of farmers the men in the bigger businesses share their information only with similar men. If they are not buyers, one of them may give a favoured small farmer a hint or a suggestion, but the men of the smaller business only get to know the opinions of the " bigger men " by observing their actions. Of such is the type of information obtained by personal observation and intercourse. Doubtless practice and experience of this kind of information-gathering and judgment makes the results better than they would be in the case of a novice, however well equipped intellectually, but still they remain vague and uncertain, and the man who is furnished only with them postpones his final judgment until he actually faces the dealer and can judge his attitudes.

There is, however, always a danger of ill-founded statements or rumours gaining currency. A rumour of a slump or of a keen demand in another area or an adjacent market gets exaggerated, and markets show a little dislocation until the effect of the rumour is dispelled. Occasionally also other ill-founded statements are made. There is reason to believe, for instance, that the publication of the fact of increase of sheep stocks in August, 1925, and rumours founded on that had a little effect on the ewe sales of Wales in the autumn. The actual increase in total number of sheep in England and Wales was only four per cent. over the previous ten years' average; but in ewes was nearly six per cent. In Wales alone the increase in total sheep was under 150,000 or 4.3 per cent. and that in ewes 73,000 or 4.4 per cent. over the numbers for 1924. This increase was quoted in a group of farmers as " a million increase in Wales ", and the query was put: " What can you expect of the sheep trade with that? " There was no indication that the total had stood at a far higher figure even as late as 1917.[5] This may be a case in which exagger-

[5] Prices of different classes of store sheep fell by amounts varying from 10 to 16 per cent. between September-October, 1924, and September-October, 1925. The average fall in Wales would not be less than about 12 per cent. It is not suggested that the fall in prices was wholly due to increase in numbers or rumours of this. Other influences were at work, notably the feeling of feeders that the margin between store sheep and mutton or lamb prices had been too narrow. The light root crop in England also had an influence.

ation was greater than is general, but when farmers are faced with any strong statements relating to supplies they have little idea of any methods of checking them, and can only judge their accuracy on the standing and the character of the persons who make them, or test them by a vague sense of probability. In groups and individually they are susceptible to suggestion in matters on which their sources of local information are poor.

The customary sources of printed information are meagre and weak. Few copies of the *Agricultural Market Report* circulate on Welsh farms. The *Farmer and Stockbreeder* quotations are frequently read, but they do not always include stock of the type the farmers have to sell. As regards sheep, they afford little or no information which is of use to the hill-farmer. Moreover, the prices quoted for Welsh markets are for centres in the better districts. The local papers sometimes give a column of paragraphic quotations for different centres, many of them in England. The following samples culled from a paper in September, 1925, show the weaknesses of such quotations: " T———. Cows and calves to £84 ". " Fat lambs 74s. 6d., fat ewes 41s. 6d., breeding ewes 62s." Sometimes there is a statement " sheep a worse trade ", but the market may not have been quoted for the previous week. " A good clearance " is recorded, but there is little if any indication of supplies and none of numbers. On occasions a careful and methodical analysis would be necessary if real information were sought from these columns of quotations. There is no continuity in the quotations for particular markets; but the chief defect from which the information suffers is failure to indicate quality and total absence of unit values (as by weight) except per head. While such information may have its uses, it is very much of the same character as that gained in the private treaty markets; it is vague and unconnected.

Altogether, the conclusion is forced on observers that the chief sources of information are personal, and that definite judgments are not made until selling begins. When sales are to dealers, as they frequently are, the dealer's attitude towards the stock is the best indicator of the possible price available to the farmer for his immediate and practical purposes.

If the dealer were concerned only with supply and demand and comparative prices—with general economic factors in the transaction—this might not have bad results. But the astute dealer is as much concerned with the mind and the character of the man with whom he is negotiating as with the " market ". It is not often that an opportunity occurs for an observer to

watch a dealer at close quarters in his transactions with individuals on farms, but they can be heard and watched quite closely in some of the open treaty markets. And some analysis of methods may be useful.

The dealer as prospective buyer generally cannot dissemble or deny his desire to buy. He may not desire to buy a particular lot, but then he is not the active promoter of the possible transaction. There may be times when he is either more or less ready or anxious to buy than normally, and these depend on the markets, recent experiences and assessment of prospects of particular profits. But in general he gets his living by buying and selling, and must continue with transactions. Moreover, it is good for a dealer to have a reputation for buying all or a large proportion of a given class of stock which is on sale. Thus it is difficult for him to dissemble his desire to buy if this exists at all, and in any case the prospective seller will assume the dealer's desire to buy if the preliminaries of a bargain are begun.

The potential seller may be in an active or a passive condition. He may not desire to sell, but he may be willing to make the choice between keeping and selling that of selling if the price induces it. Here perhaps is the most frequent possibility of reaching the maximum market price. Even in such a case the dealer may use all his arts to attain his end. When the prospective seller shows an active desire to sell, and when his need of selling is evident, then the dealer's arts are given full scope. The goods may or may not be sold at or near their maximum market price as a result of the conflict between the two minds and characters. It is a great mistake to think that the private dealer always depends on financial interest to gain his ends, for there are many known cases of dealers buying products—particularly cattle—at prices which are known to be lower than those expected or obtainable elsewhere. The trouble and expense of obtaining the higher price may be greater than those of obtaining the lower price from the dealer, and yet the net price may be greater and still the dealer gets the stock. Indeed, the greater part of the dealer's activities on the farm represent those of a most practical psychologist. There is information or facts—or the representation of facts. " I was at ——— yesterday. Cattle were dirt cheap ". " There are plenty of cattle to come on the market ". " Grass is short in the Midlands ". " Beef is going down in London ". " So and So is not buying ". Then begins the indirect attack. " I have always bought your cattle " or " I bought your cattle last year, why not sell me these? ". " You will never forsake an old friend (or ' pal ') ". " Why

not sell to a man you know, why do you want to sell to So and So?" "Why not sell to a man who you know can pay? You can't be sure of these newcomers". And finally in general talk there is the resort to a sentimental appeal, "Don't you trust me to give you what they are worth?" This is difficult to meet, for no man likes openly to state his doubt of another. The alternative to the admission or doubt of honesty requires time and argument. The only quick reply is a doubt of his judgment of quality.[6]

The stock sought or on offer are considered but the judgment is by no means a dispassionate one. There is subtle appreciation of some animals in the bunch, subtle depreciation of others, always leaving the balance in favour of the buyer. In the end the dealer may use power—the power of inspiring mild fear or strong doubt. "The market is going". "If you take these things to ——— they will not fetch as much as I offer". "You don't want to have these things on your hands". The success of this manoeuvre depends on the farmer's information and economic position as well as on his own character; but the dealers' reputations for judgment and experience stand them in good stead. In case of a sale the dealer may use flattery or make attempts to ingratiate himself with the prospective buyer. "I am giving you the first chance". "You know a good thing when you see one". "A bunch like this is fit to go on your farm and there aren't so many fit for that". In making purchases he is frequently self-appreciative, tending to be self-laudatory. Effort is directed to establishing the idea or the feeling that his knowledge is greater or his judgment better or more reliable than that of the prospective seller.

While the idea that sales are effected on the basis of knowledge of market conditions and on assessment of economic values is largely fictional, there is an element of this in all sales. But it sets the higher and lower limits of possible price rather than fixing the actual price which is paid. Even in large auction sales in

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[6] The prices set by offers on either side and the actual stock are obvious factors in the determination of the result, emphasis is here laid on the way in which the offers are made, and the information, etc., which conditions them. But for those who are not conversant with sales on Welsh farms it may be necessary to state that neither the stock nor the prices are absolutely fixed quantities. As regards prices, "luck money" is customary, but the amount is variable in some degree. To the stock themselves services of keeping and delivery may be added and these are variable even for individual farms. Thus a farmer may offer beasts, say, at £15, when the dealer has held firm to fourteen guineas. The farmer expects to give immediate delivery if his offer is accepted, while the dealer may say: "I'll take them at your price, but I shall not want them for a fortnight", or "I'll take them, but I shall want them delivered to ———", viz., some unexpected place.

areas in which buyers and sellers are known to each other prices are not fixed in every case by economic rationalism working on market conditions. There are preferences or prejudices which have very little relation to immediate conditions and circumstances. But dispersal sales on farms afford the clearest cases of non-rational economic action on the part of farmers. They frequently give rise to exhibitions of feelings and to actions which are not based on economic considerations alone. Should the dispersal be a forced sale, attendance is often poor and prices are low. The common feeling seems to be one of shyness and reserve which amounts almost to a show of reluctance to attend. There is no keenness to obtain the goods offered, interest is flaccid, people stand round in almost sullen silence. Rather than a desire to give full value for goods, there is a negative refusal to give the creditors the best result even if there is not an active feeling against them. On the other hand, in the case of a voluntary sale, especially when a neighbour is retiring or removing to another district, it is remarkable that prices frequently exceed the real value of the goods offered. Prices of second-hand and much used goods are almost or quite as high as those of new equivalents. It has been suggested that this is due to a willingness to pay a relatively high price for the article of known efficiency rather than the higher nominal price for the apparently better but unknown article. It is also suggested that such actions are due to a desire to pay the price to a farmer rather than provide profits for the middleman. But if these were true explanations they should be equally applicable to forced sales, which they certainly are not. The truer explanation is to be found in the desire to give a good " send off " to the leaver, or " to have something of So and So's ". It is the last opportunity—possibly the only one taken—of showing kindly feeling of a practical character. A popular farmer may be sure of a good dispersal sale, not only because of the character or repute of the goods offered, but also because of his own character and reputation. The attendance is large, interest is widespread, and bidding is keen. In certain individual buyers there may be " a lively anticipation of benefits to come ", but in the group at large the desire to record good prices does not arise from economic motives. In the group consciousness of the crowd other feelings are predominant. There may be a desire " to have something of So and So's ", but there is a general desire for a happy ending of the immediate relationships between the seller and the group. There are also rare cases in which quite a different feeling exists. If a man has had a bad reputation as a farmer, and has not been actively identified with any form of

social life, his bad reputation affects the prices paid for stock and even implements to a greater degree than their economic merit warrants, for unless obviously misused the bad farming will not have affected the implements though it may have affected the stock in unseen ways. As regards the stock, there is a definite fear of its bad reputation passing with it, and a considerable allowance in price is required to overcome initial reluctance to buy.

While dispersal sales possibly present some peculiar features or exaggerate other features of farmers' attitudes to business, there is no doubt that similar though weaker preferences and prejudices are observable in other circumstances. There is nothing more certain than that it pays a farmer to have a reputation for having good stock, or *vice versa.* One man may have as good a bunch of stock as another, but if his reputation is for producting poor or mediocre stock his price will be lower, especially when markets tend to be slack. One advantage accruing to the farm or the farmer having a good reputation is that his stock is sought at an early stage in the market, or, on the farm, early in the season of the year when the type of stock is usually marketed.

There is also a very considerable element of " goodwill " active in the sale of livestock. In areas in which different types of land occur, and where different lines of production are carried on almost side by side, there is a large amount of buying by farmers—as of stores for feeding, or ewes for early lamb production. In such cases the fact that one farmer has bought sheep from another farm for several years in succession often makes the vendor very anxious to sell to him again. But the dealers also put a considerable amount of trust in good faith and goodwill. It is not at all uncommon to see on a farm a bunch of stock that ought to have been marketed and to hear the explanation : " Yes, ——— (a dealer) promised to come last week, but he hasn't been yet ". The visit is sometimes delayed for two or three weeks and still the sale may wait for him. And it is common practice for a dealer to buy the livestock which is for sale in a parish or a number of parishes from a large proportion of farms for several years in succession. In such cases farmers do not usually offer their stock to any other farmer or dealer until the regular buyer has seen it and made his offers. Sometimes a promise is made or implied in the terms of one deal that the buyer is to have the first chance of purchasing in future. And there are occasions when sellers suffer from the fact that the dealer does not arrive in the district or on particular farms until

late in the selling season, by which time the farmer may have but little opportunity of selling elsewhere should he fail to make a bargain with the particular dealer. These cases tend to be more frequent in times of slack markets or of depression.

In the case of transactions between farmer and farmer in the ordinary way of business there are sometimes curious manifestations of non-economic feelings on the part of sellers. A large feeder of cattle in a good farm, on the edge of a district of small farms on land of mediocre quality devoted to stock raising, states that he now always employs a small dealer to buy his stores from his neighbours because he thus obtains them more cheaply. The dealer can afford more time for individual transactions than the farmer is willing to give. More important, probably, is the fact that in appearance and mode of living he is more like the small farmers from whom he buys. When approached by the feeder himself the attitude of the sellers is that " he can afford to pay ". " Look at the beasts he sold last month ". " In two months he will make these beasts worth ——— ". Perhaps the ruling feeling of the sellers is that they do not object to the profit of the small dealer as much as they object to providing profits for the, apparently, richer farmer. In any case, this feeder states that he has frequently made offers for bunches of stores and having failed to buy has later bought the same beasts at lower prices after paying his dealer 2s. 6d. per head for his work.

While some sales of all types, but more particualrly of fat stock, are made within a reasonable amount of time and with little trouble, there cannot be any doubt that many of the present methods of selling livestock in Wales are clumsy and inefficient. Where unit weights are ascertainable on the farms, as in the case of porkers, fat lambs, and fat calves, one element of uncertainty tends to disappear.[7] The element of quality still remains to be judged by eye and hand, by breed and by the experience of the buyer and seller; and will remain as one of uncertainty for a number of years. But the chief requirement here is one of more information, and this is dependent upon more publicity regarding farmers' sales unless some method of acquainting farmers with conditions and prices in the dead-meat markets is found. In regard to other stock it appears that methods are unlikely to change very rapidly or at all radically in the immediate future.

The waste of time involved in selling by the existing methods is not limited to the time spent with the dealers on the farms or

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7 This will also apply to fat cattle, i.e., " fit for immediate slaughter ", sold in auction markets under the provisions of the new Act (Markets and Fairs [Weighing of Cattle] Act, 1926).

in the open markets, but is increased by attendance at markets for the preliminary gathering of information, for even selling on the farm does not make much if any reduction in attendance at markets. Altogether, too much effort and time are expended in working an inefficient system. The farmers who are fairly good producers are not necessarily good salesmen and their returns are diminished by any failure in selling capacity.

If farmers as a group, or as groups according to their chief livestock interests, were interested solely in the economic results of their work they would relinquish most of the present systems of marketing and proceed to develop others. The plain fact is that in many areas they are not so interested, or that they have never felt sufficient economic pressure to induce them to break their habits and customs and their present connections with other men. It may possibly be argued that the existence of the present systems is proof of their economic efficiency or of the satisfactions they give. If, however, farmers' complaints are any guide they do not give economic satisfaction. There can be little doubt about the other satisfactions. Many farmers look forward with pleasure to the half day which they expect to spend with a dealer, many others would not, at present, trust other men to sell their stock by any method whatsoever. Even women—widows of farmers—have the same feeling, for they can occasionally be seen in the open markets receiving offers for their stock.

If advance is to be made it will only succeed under considerable economic pressure and under strong and trusted leadership, and possibly only if both work together. Advance to any other systems requires not only the inculcation of new ideas but the breaking of a set of very strong human connections and the building of a whole new set of human relationships and confidences. Without grave individual causes it is very difficult to break human relationships in the farming community and almost more difficult to establish others that cannot be tried tentatively and with considerable reserve. For any change in methods that is likely to become permanent the leadership of those sellers who are able to do best under the present system is, practically, essential. It is, indeed, doubtful whether advance can be made without their active assistance and support, for they are the natural leaders in this line of farmers' activities.

The auction mart, especially when organised by farmers themselves, provides one method of advance which is likely to yield good results. And for the more backward areas it is quite useless to advocate other metnods of more theoretical efficiency at the present time. But some statements of the Linlithgow

Committee apply to Wales, though not specially intended to do so. "The farmer appears occasionally to lack the confidence in the auctioneer which is essential" to the success of the marts or to securing fair prices for sellers. "There is a feeling that in some cases the auctioneer is more concerned with pleasing buyers by selling cheaply than with realising a good price for his farmer customers."[8] This may be a traditional suspicion rather than a well-founded complaint, as the Report indicates, but suspicion might be eradicated if men were rational and could get information. It might best be eradicated by farmers' control of the marts and employment of the auctioneers. There are auctioneers in private businesses "who frequently, by the weight of their influence, can ensure that fair prices are paid." There are such in Wales, but there are cases in which the poor patronage of the marts has led to the auctioning of livestock being left to the auctioneers of least standing. But there are also districts in which farmers look very closely at the small commission paid to the auctioneer and regard it as an unnecessary expense in marketing. The dealer's profit, which is much greater, is not so obvious or so directly paid.

The development of strongly supported auctions would at least bring greater publicity and more accurate information into the system of marketing. Together with the weighbridge, and the publication of weights wherever applicable, the auction would remove uncertainty with regard to local prices per head and a part of the uncertainty with regard to unit values. As regards the weighbridge, the words of the Linlithgow Report can scarcely be improved. "So long as animals are not weighed before sale, the success of any bargain, from the standpoint of the buyer or the seller, must depend on the skill and judgment of the parties concerned." While farmers may be "sound and excellent salesmen developing judgment by eye and hand" to "an extraordinary degree of precision," in general they cannot compete with men "whose sole business it is to deal in stock and with whom the capacity to form an accurate estimate of live and dead weight is an essential trading asset." Still "many farmers who have no special skill or reputation as judges make no effort to exercise their option of requiring the weighing of their stock" and "are generally apathetic" to the weighbridge. "This may be partly attributable to the discouragement and obstruction of other interested parties."[9] It is not wholly so, for it is in part due to farmer's pride—unwillingness to admit inability to trust

[8] *Report on Meat, etc.*, p. 18.
[9] *Interim Report on Meat, etc.*, p. 24.

judgment as others do, and the fear of being an innovator. If the best judges would weigh others would gladly imitate them.

Information is the most important element of sound marketing which is required at the present time. Even if auctions secured publicity for local prices, a better service of information from the broader markets would still be required. And the effect of sound reliable information would not only be found in prices; it would probably be felt also in production, for one of the great drawbacks of the present systems is their inefficiency in directing the attention of farmers to the types of goods the ultimate markets require and for which they are willing to provide remunerative prices. So long as the dealer can buy and sell at a profit he is not much concerned about production. He may make definite suggestions to a few farmers, also his preferences are made known in differential prices, but the process of adaptation of production to ultimate market demands is both clumsy and slow. It is now largely one of imitation, and only information could make it one of thought or of conscious direction. As regards information on prices, however, it would be an advantage if efforts were made to collect and disseminate more information of the results of markets in Wales. There might be some difficulties in respect of the open markets, and still more in respect of the seasonal and special fairs, but anything which secures an improvement on present conditions would be worthy of consideration. Public authorities are at present very badly informed as to the needs of markets, apart from sanitary matters, but if they and their officers were interested in practical improvement of marketing processes much help might be derived from them. The organisations of farmers now in control of auction marts would render a great service to their clients and to the general farming public if they would require their auctioneers to make a careful report of prices realised at each mart and supply them to local newspapers. The circulation of such reports between the societies concerned and to Secretaries of the Farmers' Union for Press or other publicity service might also be organised.

The most important factor in the general possibility of making improvements is that of leadership in action. Analysis of the present systems, and particularly of their results, would yield information which would show their inefficiencies in ways which producers would recognise and suggestions for improvements could be made. But information of this kind, even with suggestions for modification of existing systems, will not exercise much influence on the minds of great numbers of sellers. Active leadership in innovations and organised movement is required to

bring any new systems into successful working. The individual innovator now often suffers for his temerity unless he can find a market quite outside the range of local influences. For those types of stock which inevitably must find a local market in the first instance organisation is essential to new methods of marketing. Such organisation is dependent upon the support and leadership of the strongest farmers in each locality.

FARMERS' COSTS OF MILK DELIVERY IN WALES.

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There are several distinct milk-producing areas in Wales in which the trade is mostly of a wholesale character and in which the farmer's services of delivery are mainly limited to cartage to station with payment of rail freightage, or cartage to depôt. In some of these areas collection systems have been organised by purchasers, so no direct costs are incurred by farmers. Such wholesale milk areas are to be found in parts of the counties of Glamorgan and Monmouth, Pembroke and Carmarthen, and Denbigh and Flint, although individual farmers and small groups are to be found supplying liquid milk in wholesale quantities in other areas. But all over the country are to be found producer-retailers of milk who supply the larger villages and towns in the vicinity of their farms. Outside the wholesale districts this is the distinctive feature of the trade in liquid milk in Wales, and in the industrial districts of South Wales and parts of North Wales large quantities of milk are sold retail by farmers. In some such areas more liquid milk is sold by the retail than by the wholesale method. Indeed, many farmers whose farms are not situated in districts in which the wholesale trade is well organised look to the retail system for the possibilities of an increased trade in milk and are interested in its conditions. Breconshire is fairly representative of some of the areas in which butter-making and retail sale of milk provide its chief outlets.

Although no comprehensive survey of the costs of distributing milk has yet been made, information on costs under different systems is available for forty-one farms in Breconshire and sixteen farms in the counties of Pembroke, Carmarthen and Denbigh. These farms provide examples of almost every system of

distribution which exists in the Principality. The information for Breconshire farms was obtained by the "survey" method—by visits to farms, consultation of such records as were available, estimation of unknown quantities, and observation. The information for other farms was given in monthly records by the farmers concerned, but certain items, such as cost of keeping horses, have been subject to estimation.[1]

No specific statements of rail charges are required, for every farmer can obtain information on this point as regards costs between particular stations of dispatch and delivery; and under normal circumstances general information can be obtained from the scales of charges issued by railway companies. Nor is it possible to state an average applicable to the whole of Wales. The range of rail charges for the group of Breconshire farms is between 0.78d. and 1.56d., with an average for the group of nearly 1⅓d. per gallon. For other farms the range of rail costs is between 1.18d. and 1.84d., with an average of 1.26d. per gallon. But the figures for these farms are not put forward as representative of general conditions in the Principality.

Methods of collection of milk from farms and the respective charges vary from district to district and from farm to farm. A retailer may send for the milk of one or two farms and pay a price from which no deductions are made. A farmer who retails may buy milk of another farmer and fetch it with his own cart. Some large producers sell to more than one purchaser, when part of the milk may be delivered and the other collected at the farm. Where the general method is to deliver from the farm the Sunday milk may be collected. But where the general method is collection by the wholesale buyer conditions are subject to arrangement.

Wholesale Delivery in Breconshire.

By far the greater quantity of milk produced for liquid consumption, probably 75%, and excluding the industrial districts, about 90%, is delivered direct to the consumer by the producer, who thus in his capacity as producer-retailer does away with the necessity of a wholesaler.

Every producer, however, does not distribute the milk produced on his farm. He may sell it to a retailer who lives in his own district or he may despatch it by rail to a wholesaler or retailer in a consuming centre. A few farmers adopt the first

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[1] Mr. H. J. Meredith was responsible for the Breconshire Survey, and partly for collection of other records. Mr. J. Pryse Howell has been responsible for some collection and for the subsequent work on other records.—A.W.A.

method, and in such cases the retailer generally collects it from the farm, so that the producer does not incur costs of delivery.

A large number, however, produce milk for consumption in an industrial district several miles away, such as Ystradgynlais, Merthyr, Dowlais, Fochriw. In such cases distribution costs, apart from the capital outlay, include conveyance of milk to the local station, the return of the empties to the farm, and also railway charges for the carriage of the milk to the buyer's railway station. The farmer has to be responsible for the delivery of the milk at the buyer's station in a pure state; and for any loss, sourage, or contamination of the milk making it unfit for distribution he is held responsible. Farmers occasionally supply some or all of the churns used for the conveyance of the milk, thus adding to their expenses of delivery.

Most of the farmers who rail milk send it to the industrial areas in the south of the county or across the border into Glamorganshire. The distance varies according to the town or district to which the milk is sent and the station from which it is railed. By far the greater quantity, however, is sent by rail over distances within the 20-40 miles limit. The usual charge made by the railway companies for milk sent this distance is at the rate of 1.17d. per gallon for a minimum quantity of twelve gallons. This rate is for conveyance " at owner's risk."

Special charges are made by the railway companies where milk has to be hauled over the line where there is a steep gradient, long tunnels, or long railway bridges over mouths of rivers, etc. As such gradients, tunnels and bridges entail a greater expense in upkeep in proportion to their length than does the ordinary permanent way, extra charges are made for the conveyance of goods over such lengths, and thus the amount payable on milk is greater than that in the companies' schedules. Some of the milk exported from the county is sent to Merthyr, Dowlais, etc., and passes over a steep gradient extending for several miles. Owing to this fact higher charges are levied, which on the basis of the figures supplied by some farmers amount to about 1.8d. per gallon instead of the ordinary charge of 1.17d. In the course of the year and on the exportation of large quantities of milk this must make a considerable difference in the railway charges payable by the farmer and to that extent reduces his returns.

The ordinary railway charges are, however, if the pre-war charges be considered equitable, not unduly high, as the present rates are, on the average, about 51% above the rates prevailing at that time.

Milk is despatched by passenger train usually once a day, although most of the farmers who are selling to wholesalers send away Saturday evening's milk that night, Sunday morning's milk being used for butter-making owing to lack of facilities for railway transport.

Nearly all the farms under consideration are situated within a comparatively short distance of the railway, but in nearly all cases a pony and float or other vehicle is needed to convey the milk to the station. As ponies or motors are generally used to some extent for other purposes only a part of the expenses of upkeep can be allocated to the cost of delivering milk, in a proportion determined by the time spent in going to the station and the extent to which the pony or car is used on other work. Apart from this, farmers who purchase feeding stuffs, etc., for their stock often bring them back on returning from the station. Even if only one hour is spent in delivery to the station a greater proportion of the cost of upkeep must be allocated to the milk than one hour's work daily if the pony is kept mainly for this purpose.

The highest costs for delivery to buyer's station, rail charges being equal, are found in those cases where farmers live some distance from the station and deliver comparatively small quantities of milk. Without rail the general range of costs is between ½d. and 1.8d. per gallon. The lowest cost is found on a farm where a motor lorry is used for delivery, the farm being situated about 1½ miles from the station and delivering about forty-three gallons per day. The highest cost is found on a farm about 2½ miles distant from the station where only twelve gallons per day were delivered. In one or two cases ponies were kept chiefly, if not solely, for the delivery of milk and this led to an increase in the cost of conveyance. Almost every farm supplied three or four churns, repairs and depreciation on which added to the cost of delivering the milk. The cost of delivering to the station is fixed per load, and there are many cases in which an increase in the load would be possible and a reduction in cost per gallon could be secured. On certain farms near Crickhowell milk is collected by the wholesaler. In such cases the ruling prices are about 2d. per gallon lower than for milk delivered at the buyer's station.

While this indicates the general method the actual position on some individual farms is best shown by examination of the costs incurred in delivery.

In the assessment of costs, the cost of keep of horse or of upkeep and running motors, and depreciation on the total equip-

ment, have been totalled. Only a proportion of the costs of keep and depreciation of horses or vehicles, according to proportion of time worked, have been charged to milk. The full depreciation on churns, cans, measures, etc., has been charged. Depreciation on horse equipment has been allowed at 10%, but on motors at 20% per annum. Interest on capital proportions is also included, but alternative costs not including interest are given.

TABLE I.

Costs of Wholesale Delivery—Breconshire Farms, 1924-25.

Method of delivery.	*Approximate daily average delivery.*	*Total annual delivery.*	*Total Cost including interest*	*Cost per gallon.* Including interest charges.	*Cost per gallon.* Less interest.
	Gallons.	Gallons.	£ s. d.	Pence.	Pence.
Motor	44	16,060	44 11 8	0·67	0·61
Motor	50	18,250	96 7 0	1·26	1·19
Motor	25	9,125	64 9 0	1·69	1·55
Motor	32	11,680	86 10 0	1·77	1·67
Horse	25	9,125	42 13 8	1·11	1·02
Horse	15	5,384	30 19 0	1·38	1·09
Horse	20	7,300	44 13 0	1·46	1·39
Horse	28	10,402	64 9 6	1·48	1·42
Horse	26	9,307	61 2 6	1·57	1·49
Horse	12	4,380	51 0 0	2·79	2·60
Push Cart	8	2,920	20 10 0	1·68	1·64

Manual labour accounts for about half the total costs, but the amount of manual labour-time may exceed that charged for horses or motors, as occasionally time is charged for washing utensils or other preparation. The manual labour costs are high. Most of the delivery work is done by farmers or their relatives, and the rates charged are 9d. and 1/3 per hour for " horse " and " motor " farms respectively. In the case of the push-cart delivery nearly the whole cost is for manual labour. The summary of costs for the farms using horses and motors is given below.

Summary of Total Costs.

	Horses. (6 *farms*).	*Motors.* (4 *farms*).
	£ s. d.	£ s. d.
Proportion of cost of keeping (or running) and depreciation ...	104 6 8	131 10 0
Interest on capital ...	17 2 10	19 3 4
Repairs ...	17 10 0	5 0 0
Manual labour ...	155 18 3	186 4 4
	£294 17 9	£291 17 8
Total gallonage delivered ...	45,898	55,115
Cost per gallon ...	1·54d.	1·27d.

Wholesale Delivery in Other Areas.

In other cases for which information is available a small amount of retailing is carried on with the main system of supplying milk in wholesale quantities. Small quantities are sold at the farm-house door in some instances, and in others small quantities are delivered to one or two retail customers living near the farm. Hence in the examples below a column is given showing the proportion of retail sales to the total deliveries. It is very difficult to assess the cost of selling retail at the door or even delivery of very small quantities to one or two customers. In some cases no " costs " in the form of actual expenditures are incurred, although someone must take the trouble to sell at the door or to deliver.

TABLE II.

Costs of Wholesale Delivery—Other Areas, 1924-25.

Method of Delivery.	*Delivered Wholesale.*	*Delivered or sold Retail.*	*% of Wholesale to Total.*	*Total Deliveries.*	*Total Cost.*	*Cost per Gallon.*	
						Including Interest.	*Less Interest.*
	Gallons.	*Gallons.*		*Gallons.*	£ s. d.	*Pence.*	*Pence.*
Motor	22,253	459	97.9	22,712	14 10 7	.47	.42
Motor	9,183	939	90.7	10,122	78 9 0	2.05	1.79
Horse	9,993	96	99.0	10,089	21 6 5	.51	.46
Horse	39,289	776	98.0	40,065	61 3 11	.36	.34
Horse	8,271	366	95.7	8,637	19 8 3	.56	.52
Horse	10,718	730	93.6	11,448	37 13 9	.84	.76
Horse	22,203	14	99.9	22,217	42 3 0	.45	.38
Horse	11,918	—	100.	11,918	46 9 6	.93	.85
Horse	10,690	—	100.	10,690	27 16 5	.62	.53
Horse	9,666	—	100.	9,666	42 1 6	1.03	.96
Horse	12,261	288	97.7	12,549	43 10 2	.83	.79
Horse	16,883	358	97.9	17,241	96 19 3	1.35	1.19
Horse	7,245	—	100.	7,245	28 11 4	.94	.84
Horse	7,075	—	100.	7,075	37 17 5	1.28	1.16

The summary which follows indicates lower costs than those found in Breconshire, but although there is probably some reduction due to the small retail sales at or near the farm this is very small. Excluding the retail milk the cost where horses are used is 0.70d. and where motors are used 0.90d. per gallon.

Summary of Total Costs.

	Horses. (12 *farms*).	*Motors.* (2 *farms*).
	£ s. d.	£ s. d.
Cost of keeping (or running) with depreciation on equipment ...	206 7 8	78 8 0
Manual labour ...	198 2 10	24 19 1
Repairs ...	15 15 6	10 6 0
Interest on capital ...	51 14 10	14 15 6
Total charges ...	£472 0 10	£123 8 7
Total gallonage ...	168,840	32,884
Cost per gallon ...	0·70d.	0·90d.

The difference in costs here and those previously given is due to heavier deliveries and possibly to shorter distances. In Breconshire the average annual delivery for six farms using horses is 7,650 gallons, while for other areas the average annual *wholesale* delivery for twelve farms using horses is 18,850 gallons. Of farms using motors the four in Breconshire had an annual average delivery of about 13,780 gallons, while the two using motors in the other areas had an average delivery of 15,720 gallons per annum. The labour costs are lower, partly because the rates average about 7d. per hour for persons with horses and 9d. per hour for men with motors. The labour of some boys or youths is used for delivery by horses.

Methods of Retailing in Breconshire.

One of the most striking features in the sale of milk within the county is the large number of farmers, butchers, etc., who deliver milk in varying quantities. The growth in the number of milk vendors took place during the period of war when prices were at a high level, and during the two or three years following the number was again increased. Large and small farmers, smallholders, butchers, grocers, etc., all apparently believe—or at least believed—that milk selling was a profitable business, and consequently they tried to share in the profits thought to be obtainable. Where three or four farmers on the outskirts of a town at one time catered for the needs of all its inhabitants one now finds not only other farmers in the market, but a number of town residents who have been able to secure a few acres of land on which to keep cows. Some of these keep only two cows, and possibly only one for part of the season, producing an average of three to four gallons which is delivered by can to from twelve to twenty houses. Others have a larger number of cows, a little more land, and still distribute from cans or possibly with a truck. Figures are not available for 1914 showing the number of milk vendors in every district, but some idea of the growth in the number can be obtained from figures given for Brecon, according to which there were only five milk vendors delivering milk in 1914, while the number in 1925 was twenty-eight. The difference is not by any means as great as the figures would suggest, as at the former date a number of milk vendors who only distributed small quantities were not included, while all who sell and distribute milk are included in the figures for the later year. It has, however, been estimated that the number has been at least doubled during and since the war.

By far the greater number of dairy farms are near a consuming district, and where convenient most farmers deliver

the milk themselves direct to the consumer. This may, however, not always be necessary. The simplest method is for the consumer to fetch the milk from the farms. This method is adopted in every town and village to a certain extent, although it is probably more common on farms near industrial districts than on farms near rural towns. In certain districts the consumer prefers going to the farm and obtaining the milk, often while it is still warm, to the alternative method of being served by the milk roundsman. If milk is only delivered once a day this is the only way in which the evening's milk can be obtained fresh. On some farms the price of milk sold at the door is 1d. per quart less than that of the milk delivered, but the practice of lowering price in such cases is not general, and at the greater number of farms the price is the same. The producer finds it troublesome to be continually selling at the door, many consumers calling hours after the milking has been completed, and although some consumers regularly collect their milk from the farm many who call for milk are those who want an extra supply which they were unable to obtain from the roundsman. It seems, therefore, that the producer, although he saves the trouble of delivering, is not to be blamed if he makes the same charge as for milk delivered.

More often, however, the milk is delivered by the farmer direct to the consumer by (1) pony and float (2) hand truck, and (3) cans. Large quantities, or any quantity over eight or nine gallons, are usually delivered by pony and float. Smaller quantities are delivered by truck or with cans, the latter method being more common, especially where two or more members of a family take part in delivery. The choice of method does not depend entirely upon the quantity, but also, partly, upon the labour available, and distance between the farm and the customers' homes. If the consumer lives within a short distance of the farm, and especially if the children help in delivering, then cans are generally used.

Not by any means all producer-retailers deliver twice a day, although in a few cases milk is retailed twice a day in the summer and once a day in winter. Some producers deliver twice only to a few large customers, such as hospitals, hotels, boarding houses, etc., while a few deliver twice to a big proportion of their customers. Those producer-retailers who live at some distance from a town are seldom able to deliver more than once.

The retail price of milk is generally 1d. per quart dearer in winter than in summer, the average for the winter of 1924-25 and summer of 1925 being 7d. and 6d. respectively, although at

Builth the price remained 6d. summer and winter, while at Hay it was 6d. in winter and 5d. in summer. At Llanwrtyd and Talgarth the winter and summer prices were 7d. and 5d. respectively—a difference of 2d.

The quantity of milk produced being relatively small on the greater number of these farms, and delivery taking place immediately after milking, only in a few instances have cooling apparatus been installed.

Surplus milk is manufactured into butter and sold at the weekly produce markets. Only small quantities of cream are sold. Occasionally consumers come directly to the farmhouse door for it, while some milk vendors, and one in particular, take a supply of cream in specially prepared small bottles for sale when delivering milk to consumers.

Cost of Retail Distribution in Breconshire.

Owing to the widespread interest which has been shown of recent years in the sale and distribution of milk and the relative shares of final price obtained by the farmer, wholesaler and retailer respectively, where these three are found, it is of some interest to discover as far as possible what are the costs of distribution in a county in which milk is produced within a few miles of the town or district in which it is consumed and where the distributor is generally also the producer. A certain quantity of milk is railed to such places as Ystradgynlais and Brynmawr and is sold by retailers who are not producers. But even here the greater quantity comes from farms within a few miles of the district in which it is consumed, so that by considering the cost of producer-retailer distribution a fairly accurate estimate of costs will be obtained.

It must be realised, however, that it is much more difficult to calculate actual costs of distribution in the case of a producer-retailer than in that of the retailer who purchases directly from a producer or wholesaler. In the latter case practically all costs can be attributed to distribution, but the costs are much more complicated where the producer distributes his own milk. In such cases the farmer spends only part of his time distributing, for the remainder he is occupied with the work of the farm. Again, the pony used for delivering milk is probably also used on the farm, but here the question arises as to whether the pony would be kept for this work if milk was not delivered. If kept primarily for milk distribution then the whole expense of upkeep of the pony would be attributed to milk distribution, but if such a pony would in any case be kept for other farm purposes only

a due proportion of the expenses of its upkeep should be allocated as to this service. More difficult still is the apportioning of the time spent in distribution in the case of very small distributors, such as butchers, etc., or where children deliver all or the greater quantity before and after school hours. This simply demonstrates the difficulties inseparable from such an enquiry, but as far as possible only those costs which are directly attributable to the cost of distribution have been included, while only those instances where it has been possible to allocate costs fairly accurately have been chosen.

Milk is delivered most cheaply at Llanwrtyd Wells, where it is delivered only once a day. This is a small town where the producer-retailer lives either in the town or immediately outside, while the land is not by any means as dear as that in other parts of the county. Apart from this the cost per gallon delivered would be very much greater if the summer delivery was only equal to that delivered during the winter months, but Llanwrtyd being a summer health and pleasure resort, with an influx of visitors during the summer months, the producer-retailers are fortunately able to dispose of their supply without any difficulty and the delivery of large quantities to the hotels and boarding houses makes their distribution more economical.

Delivery is mostly by pony and float, but quantities are carried in cans. The latter proves cheaper here, as the producers live in the town and deliver to two or three hotels.

Distributors in other districts, such as Crickhowell, have only a small delivery cost. Here the producer lives within a short distance of the district in which he delivers, and costs of distribution are low because of the economical delivery by truck or cans.

Higher costs are experienced in and near Brecon, Abercrave, Ystradgynlais and Hirwain, where land is dearer and where many of the producer-distributors live some miles out of the town.

Another interesting comparison is between costs of distributing large and small quantities of milk respectively. Highest costs fall upon distributors who only deliver small quantities and yet are saddled with almost the same expenses as those distributors who in some cases deliver three times as many gallons.

Considering first those who deliver with a pony and float it is at once seen that highest distribution costs fall upon those who have to take the milk two or three miles before delivery commences, while those farms in or near a town have high costs if entirely dependent upon highly rented land on the outskirts

of the town. Whereas, however, the costs in the former case are mainly due to time spent in delivery, the high costs of the latter are due to higher expenditure on foodstuffs, etc., for the pony and also higher labour costs. Generally, however, costs are greater from outlying farms.

One of the highest costs of delivery was found in the case of a distributor who only delivered an average of less than seven gallons per day summer and winter, and yet kept a pony and float for this purpose. His distribution cost reached a yearly average of 7.25d. (including interest) per gallon. In the same town another milk vendor distributed an average of forty gallons per day throughout summer and winter at a cost of delivery of 3.87d. per gallon, but only one pony and float was kept, there being greater total labour costs but relatively much less than in the former case. In every other district the same conditions obtain, the distribution cost per gallon being very much higher where the same capital outlay and almost the same running costs are incurred by distributors delivering small quantities as by other distributors delivering very much larger quantities.

In the same way distribution costs are higher for those milk vendors living some two or three miles distant from the areas of distribution than for those who live on the outskirts, although this is to some extent counterbalanced by the lower total cost for the upkeep of the pony. In comparing the costs of distribution per gallon of milk delivered by means of a pony and float with that of milk delivered by truck or can, the results are less conclusive.

One producer distributing nine gallons per day with cans had an average cost per gallon of 6.72d., almost as high as that incurred in the highest pony and float delivery. The extra labour involved accounted for the excessive costs in this case. Other examples can be given where the same result is seen, due again to the extra labour costs incurred in delivery. Where, however, only very small quantities up to six gallons are delivered, especially if the producer has not far to carry the milk, the cost may be very low. In three cases it was less than 8d. per gallon. As such delivery is usually carried out by a producer before beginning a day's work or by women, or possibly school-children, there is but little scope for development.

It is thus seen that distribution costs per gallon incurred by producer-retailers are on the whole comparatively low, although there are great variations, viz., from less than 8d. per gallon delivered in cans when only four gallons were distributed daily, and less than 8¼d. where over forty gallons were distributed daily

by pony and float, to nearly 6¾d. per gallon for delivery of nine gallons in cans and 7¼d. per gallon for delivery of less than seven gallons with pony and float, and again 7½d. for delivery of about twenty-eight gallons daily with two horses and floats.

The maximum amount which can be delivered by one pony and float depends upon the distance which the roundsman has to travel and the labour involved. If delivery is in a number of streets within a short distance of each other, less time will be taken and a greater quantity can be delivered with less labour than where the round is a scattered one. Considering the time taken, capacity of churns, and labour involved, it seems that generally in country towns, at any rate, 40-45 gallons is the maximum quantity economically distributed.

The delivery of larger quantities entails extra labour costs and also a delivery lasting several hours, so that it is a late hour when the last consumer is served, a point thus being reached beyond which delivery by one pony and float becomes less economical to the retailer and unsatisfactory to the consumer.

The summaries of total costs are given below, where it will be seen that manual labour constitutes much the heaviest item.

Summary of Retail Costs in Breconshire.

	Horses. (21 *farms*).	*Trucks or Cans.* (8 *farms*).	*Motor Cycle.* (1 *farm*).
	£ s. d.	£ s. d.	£ s. d.
Cost of keeping (or running) with depreciation on equipment ...	731 15 2	1 14 0	14 0 0
Manual labour ...	1,970 13 6	439 12 4	62 8 0
Repairs ...	65 19 0	2 2 0	6 12 0
Bad debts ...	111 19 0	4 0 0	3 0 0
Interest on capital ...	65 19 11	0 17 0	3 6 0
Total charges ...	£2,946 6 7	£448 5 4	£89 6 0
Total gallonage ...	141,620	26,918	3,285
Cost per gallon ...	5d.	4d.	6·52d.

It is somewhat remarkable that the delivery by trucks or by cans carried by the salesmen shows such low costs, but the average daily delivery under this system is about nine gallons, while the average under the vehicle system is only eighteen gallons per day. The manual labour cost is 3.9d. per gallon in one case and 3.3d. in the other, so relative labour costs are higher with trucks or cans. On the whole, the carts are not carrying anything

like the maximum amount which could be delivered by a horse and a man.

The costs on individual farms are as follows :—

TABLE III.

Costs of Retail Delivery in Breconshire, 1924-25.

Method of delivery.	*Approx. daily average delivered.*		*Total annual delivery.*	*Total Cost including interest.*			*Cost per gallon.*	
							Including interest	*Less interest*
	Gallons.		Gallons.	£	s.	d.	pence.	pence.
	Summer.	Winter.						
Hand Truck or Cans.	20	12	5,840	64	5	0	2·64	2·63
,,	8	3	2,007	23	7	0	2·79	2·77
,,	4½	2	1,186	13	11	0	2·74	2·72
,,	17	10	4,927	65	7	8	3·18	3·17
,,	12	10	4,015	55	4	6	3·30	3·29
,,	7	6	2,372	55	1	6	5·57	5·56
,,	9	9	3,285	79	6	8	5·79	5·78
,,	9	9	3,285	92	2	0	6·72	6·71
Motor Cycle.	9	9	3,285	89	6	0	6·52	6·27
Horse.	50	36	15,795	205	15	0	3·14	3·09
,,	25	12	6,752	98	11	0	3·50	3·37
,,	22	8	5,475	81	15	0	3·58	3·45
,,	40	40	14,600	237	2	0	3·87	3·83
,,	40	35	13,687	229	5	0	4·01	3·97
,,	20	3	4,197	70	17	6	4·05	3·91
,,	14	10	4,380	79	13	0	4·36	4·21
,,	30	30	10,950	225	0	0	4·93	4·80
,,	16	15	5,657	117	18	0	5·00	4·85
,,	8	6	2,555	55	3	6	5·18	4·92
,,	17	11	5,110	113	15	0	5·34	5·17
,,	10	10	3,650	86	16	4	5·70	5·52
,,	16	10	4,745	115	14	0	5·85	5·67
,,	15	15	5,475	139	1	0	6·09	5·95
,,	24	16	7,300	184	11	0	6·06	5·94
,,	17	17	6,205	163	6	6	6·31	6·09
,,	13	12	4,562	123	1	0	6·47	6·41
,,	12	10	4,015	116	10	9	6·96	6·84
,,	12	10	4,015	117	3	0	7·00	6·86
,,	8	5	2,372	71	14	0	7·25	7·01
2 Horses.	28	28	10,220	313	14	0	7·36	7·29

Retailing in Other Areas.

The costs of retailing in other areas are available for two farms only, and costs are much lower than in the Breconshire cases, mainly because of the delivery of greater quantities. These costs are for very good "rounds."

Summary of Retail Costs.

	Horses. (2 farms). £ s. d.
Cost of keeping, with depreciation on equipment ...	84 16 3
Manual labour ...	131 1 6
Repairs ...	15 8 0
Interest on capital ...	13 13 0
Total charges ...	£244 18 9
Total gallonage ...	24,204
Cost per gallon ...	2·43d.

The average daily delivery here is over thirty-three gallons per vehicle against about eighteen gallons per day for the Brecon-shire farms, while the manual labour cost is 1.3d. per gallon against 3.3d. for similar farms in the preceding summary.

Conclusion.

The average costs for the whole of the groups may be stated for convenience, although they may require some confirmation before they can be taken as representative of conditions in the Principality.

Average Cost per Gallon.

			(*approx.*) *Pence*
Wholesale Delivery	Horses	(18)	0·86
	Motors	(6)	1·13
	Total	(24)	0·94
Retail Delivery	Horses	(23)	4·7
	Trucks or Cans	(8)	4·0
	Motor Cycle	(1)	6·5
	Total	(32)	4·6

The range of the costs shown in Tables I, II and III should be more particularly noted. In this connection it may be suggested that distance should have been stated, but in a hilly country like Wales mere statement of mileage would be apt to be misleading, for the time and the limits of load for delivery are determined as much by the character of the road as by the relative distance. But if these statements of retail costs, even with their wide variations, may be trusted, they provide an explanation and a justification for the willingness of many farmers to engage in the retail trade. At recent prices no other outlet for milk has offered such remunerative possibilities. The method of disposal of milk must be determined largely by local circumstances, but it appears that farmers in favourable situations with relatively small quantities to dispose of may profitably seek a retail trade while the margins maintained by other retailers continue at their recent amounts.

SALESMANSHIP IN AGRICULTURAL CO-OPERATION.

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The subject of salesmanship and of the psychology of selling is one which has attracted a great deal of attention in the commercial world during the last few years, but agricultural co-operative enterprises have paid little attention to methods of advertising, display or salesmanship in relation to their activities. Doubtless the business of co-operative societies is different from that of individual traders. In all cases it is conducted on somewhat different principles and not for entirely the same objects. Yet the members and customers of societies are drawn from the general body of possible purchasers to which traders have to appeal, and methods which competitors use may not only be effective for their purposes but may be also both legitimate and requisite for co-operative societies. The most rigid doctrinaire of co-operation may characterise advertising as a waste of energy and money, and display as a waste of the time of staff and space in the depôt. Or the ardent co-operator may assume that every member knows exactly what he wants, that the Society will supply the best value for money in the required article, and that members will take the initiative and ask the Society for their requirements. But even such a person would have to face the fact that a large proportion of co-operative trade is conducted with non-members of societies, and if he were an agricultural co-operator he would have to admit that many members do not reach the standard of intelligence or of co-operative enthusiasm which he postulates.

Most members of societies have to be treated as ordinary individuals and methods which attract or repel members of the ordinary farming public affect them in the same way, while the non-member customers of societies do not differ in any way from other purchasers of farm requisites. It seems, therefore, that some methods of conducting business which are of importance to individual traders may be equally important to co-operative societies. Advertising, window or other display, and salesmanship all deserve consideration, but the last is of greatest immediate importance. Many farmers are not influenced to any appreciable extent by forms of advertising which appeal to other possible purchasers, and especially to women who purchase personal goods, while perhaps the majority are not attracted by

the ordinary forms of display. There are some special adaptations of advertising methods which appear to influence farmers, though there have been few experiments with special forms of display except those provided for agricultural shows. In the everyday conduct of business, however, most traders are practising the art of salesmanship even if they have never thought of the psychological principles which they are following or tried to formulate a theory for their practices.

Co-operative Trading.

The extent to which co-operative managers or agents require to practice the art of salesmanship with the general public is indicated by a study of the trading relations of the societies with non-members. The recent *Report on Co-operative Purchase of Agricultural Requisites* deals with societies under three classifications, " truck load ", " storage " and " delivery ", according to the main characteristics of the businesses carried on. Of the " truck load societies " it is stated : " it is surprising that only about one-half deal with members only ".[1] Amongst the " storage societies " " only thirteen (or one-sixth of the total number in the group) claim to deal with members only ".[2] " The remaining sixty-six societies deal with non-members, but the extent varies greatly. In many cases this outside trading does not amount to more than five to ten per cent. of the turnover, or even less, and when on this scale is probably intended to be instrumental in attracting new members to a society. In other cases, however, trade with non-members represents a very substantial portion of a society's turnover (up to as much as seventy-five per cent. in one known case), and the most regular customers are by no means always members. One society reports that, in 1923, nearly fifty per cent. of the members had no dealings with their society ".[3] Amongst the " delivery societies " " only six claim to deal with members only and in one of these cases members are authorised to order goods for non-members, while in another case, at least, sales to non-members are sometimes effected for propaganda purposes—to induce membership ".[4] " A few others sell to non-members, but to no great extent; one society admits sales to six non-members to every one member, while others are prepared to sell to anybody, but give their members preferential treatment of some sort or other. The

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[1] Report, p. 24.
[2] Report, p. 43.
[3] Report, p. 44.
[4] Report, p. 70.

majority, however, seem to make no distinction whatever, at time of sale, as between members and others ".[5]

Besides the prevalence of sales to non-members, the uncertainty of sales to members of societies makes the study of salesmanship in relation to agricultural co-operation worthy of consideration. The inability of societies to sell requisites[6] up to their capacity is not usually due to lack of desire or initiative to buy arising from hostility to co-operation, or to a particular society, in possible purchasers. It may arise from many causes, one of which may be the lack of initiative or selling capacity in the representative of the society. A recent study of the experience of co-operative " requisite " societies has led to the conclusion that inefficient salesmanship has contributed to a number of failures.[7]

Types of Buyers.

The prospective buyers of agricultural requisites are sometimes presumed to be in a different category from buyers of personal goods to whom most traders must appeal. They are buyers of raw materials to be devoted to productive objects and the assumption that they will have a good knowledge or decided opinions on the best means to their desired ends is often made. Doubtless this is the desirable condition, but in reality buyers of farm requisites differ from other possible buyers of goods only in degree. A woman may buy dresses for display or because they are fashionable as well as for protection, and a farmer will buy " cakes " because they are popular or veterinary medicines because they have been advertised in a paper he trusts. Farmers are influenced in their purchases by many factors besides the efficiency of goods as means to ends, the price of goods and service, and the comparative prices of substitutes.

In all trades in which sales are made to purchasers who use goods for personal purposes or for productive purposes which have some personal attractions (purchases not made for the purpose of re-sale) there are several types of buyers. These may be indicated as follows :—

1. The person with the intention and will to buy, with complete and definite knowledge of what he needs.

2. The person with a general intention of buying and some will to buy but only a general idea of what he needs or wants.

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[5] Report, p. 71.

[6] This paper is not concerned with salesmanship of *produce*, which requires separate consideration.

[7] *The Co-operative Purchase of Agricultural Requisites*, p. 89.

3. The person with money to spend but with only vague notions of the possible purchases which will meet his wants or give him the greatest satisfaction.

4. The bargain hunter.

There is perhaps also another type : the person who is not anxious but who is not unwilling to buy. Even under the second class, possibly, there ought to be a distinction for there is a type of prospective buyer having a general intention of buying with a good general idea of what he wants, while there is another with the general idea of needs of a certain class, but with only a very vague notion of what will meet his requirements. Thus three farmers may go to market in the spring intending to buy cake for feeding young cattle. One may be quite definite in his opinion that he requires undecorticated cotton cake, and will buy no other. Another may have the idea that he needs cotton cake, but will return as the purchaser of the undecorticated or the decorticated variety according to what is offered to him. The third, with similar requirements, may buy cotton cake of either variety, a compound " feeding " or a " grass " cake according to the persuasion or insistence of different salesmen who he has met. Another farmer may go to market without any intention of buying cakes, but finding his neighbours buying or making enquiries, or meeting an able salesman, he receives suggestions from them and actually makes a purchase. Representatives of such types are to be found in any agricultural market, and to ensure transfers of specific goods to them requires the practice of varied parts of the art of salesmanship.

There is, of course, also the prospective buyer who has wants or needs but has no cash and requires credit. He presents mainly an economic though partly also a moral question. Such credit buyers fall mainly into the second class, for the persons in the first class can usually pay cash even though by habit they may take credit and although occasionally a man with good knowledge and a decisive mind may be short of capital. The persons in the third class who are not resolved but who are not unwilling to buy will not as a rule take credit. There are, however, cases in which persons with no specific intention of buying will make purchases, when urged to do so, under the attraction of a very free offer of credit together with the pressure of a clever or insistent salesman. Such transactions, as a rule, are not fostered by co-operative societies.[8]

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[8] The credit policy of societies is usually determined by the committees of societies, though the manager or salesman may be given some latitude for dealing with individual cases within the policy. Some societies try to sell

Buyers and Sellers.

Because one cannot sell unless another buys, buying and selling is one process, although it is commonly regarded as two. The initiative in the transfer of goods must rest with the seller or buyer, but in individual transactions may rest with either in differing degrees. Sometimes the whole of it may rest with the buyer, but in cases where display or advertising has been used he may deceive himself as to the origin of desire or even intention to buy. Generally initiative in its greatest intensity is found in the seller, except in the case of the first type of buyer described above. Even in his case the initiative for the transfer of a specific article may have originated with the seller, and in cases in which there is only a general recognition of need without a decisive will to buy the initiative for a specific sale must arise with the seller. Even in a co-operative system the salesman who expects the buyer to take the initiative is throwing on him an onus of activity which he does not desire and of which the competitors of the society are quite willing to relieve him. Too little attention has been given to the personal factors in buying and selling agricultural requisites by co-operative societies. The man who stands at the store and waits is expecting more of his neighbour than he is willing to give. Although it may appear that other sellers pursue the same policy, it is frequently found that the initiative which seems to be in the buyers actually originated with the sellers.

It is possible to regard the article which is the subject of transfer as the most important factor in buying and selling, and its real qualities (or suitability and serviceableness for a given purpose), and price, as the determining factor in the results of the meeting of the prospective seller and buyer. When this is done it is assumed that men are better informed and more rational than they are and economic organisation is more consciously directed and efficient than it is in reality. Consequently it is necessary to attempt a description of the factors present in a meeting between a prospective seller and buyer. On the side of the prospective seller there is—

His personality, character and reputation,
His desire or need to make a sale,

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only on a cash basis, or for cash within fourteen or twenty-eight days. Others grant credit, but allow discount on accounts settled within a fixed number of days. Others trade on a basis which allows for credit more or less on the customers' requirements. Some societies which sell farmers' produce grant credit on a contra-account basis. The credit policy is very closely connected with the price policy of the society; and both affect the activities of the salesman and their results.

The goods to be offered,

The price or prices which he can accept.

On the side of the prospective buyer—

His personality and character, and possibly his reputation (for paying or accepting without complaint goods bought),

His need or desire to buy,

The goods offered,

The price or prices which he can pay.

The Salesman.

In nearly all selling operations there is a strong personal element and the prestige of the salesman carries a great influence. Prestige may arise from all sorts of things which produce a sense of superiority. Anything which gives the prospective seller superiority over the prospective buyer without arousing resentment or antagonism may create the prestige necessary for successful selling. Good or keen appearance, a reputation for keen or honest dealing or for having knowledge of the goods handled, are the most common causes of selling prestige, but physical size or good comportment are not without their immediate values. Physique, comportment, knowledge and character all play their part in the creation of prestige in the salesman even in the case of co-operative societies which have in their members a more or less attached body of customers. " The manager of a co-operative society, if he is to be successful, must not merely be efficient, but must be liked and trusted by the members. There are few businesses in which personality counts for so much ".[9]

In agricultural markets there is a type of insistent, even bullying salesmen, but these are not usually found in the co-operative movement. Men of this type only succeed when their contacts with buyers are irregular or infrequent. There is also a type in which insistence is linked with something akin to fraud, as when orders are booked without positive instructions being given. But some farmers are incommunicative or undecided and it is not an unknown thing for even honest salesmen to deliver without a positive order being given. " Shall I send it along?" asks the salesman, and the reply is nothing but a shrug or a look and the salesman takes his chance—usually on a credit basis. Similar transactions sometimes occur amongst co-operative sales but should only be entered into when seller and buyer know each other very well and the seller knows the buyer's usual requirements.

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[9] *The Co-operative Purchase of Agricultural Requisites*, p. 75.

Unless a prospective buyer is of the type of person who knows what he wants and has the will and intention to buy the article required, the salesman has to begin the process of selling by attracting the attention of the prospective buyer to his goods. Even the man who has the intention and will to buy may not take the initiative in approach, and it is easy to fall into the error of thinking that every cart sent to a store for a load of goods has gone there on the initiative of its owner without stimulation from the seller. For when this happens by habit it is often the result of previous activities of the salesman and the surest sign of the success of those activities. Thus unless the prospective buyer is one of the minority of people with the intention and will to buy a certain article, it falls to the seller to stimulate the will to buy. The exact process here will depend on the goods to be sold (or bought), the mind and the character of the seller, and, more particularly, the mind and character of the buyer. The two universal elements are the display or description of goods, and the quotation of price.

While a salesman's job is to transfer goods and take money or its equivalent, the actual task takes the form of conveying ideas to the mind of another person and of preventing opposing ideas arising, or of dispelling them if they should arise. When opposing ideas arise the process may be a rational or intellectual one—an argument on comparative values or services and prices if competition provides the opposing idea; an argument on the advantages of " doing it now " as against buying in the future if the opposing idea is one of procrastination. But frequently the salesman has only a vague notion, if any, of what may be the opposing idea. Then he must use his powers of persuasion or suggestion to the utmost, because logical attack is impossible.

Making Offers.

Eventually a large part of the salesman's success depends on suggestion. Every prospective buyer is an individual and the methods of the seller must be adapted to particular cases. The salesman frequently has to take his cue from the buyer's first attitude to his approach, discover his needs or desires, or his immediate attitude, and to deal with these by reason or by suggestion as may be necessary.

But one thing to avoid in selling trials is an indiscriminate offer or mention of many kinds of goods. This not only distracts attention from the goods most prominent in the mind of the possible buyer, but sometimes leads to annoyance or irritation. Rational treatment of indiscriminate offers requires thought and

discrimination on the part of the prospective buyer, and if the necessity for this causes irritation the easier way of refusing the whole lot is frequently taken. Offers need not be limited to known or habitual requirements if they are made carefully and with discrimination. When made quietly and at a seasonable time, exceptional offers are useful, for offers which are not accepted at the time of making may carry suggestions which are the origin of requirements.

In this connection the issue of price lists by some co-operative societies requires consideration. Where the customers of a society are scattered over a wide area and are not frequently to be met in one or two common centres, like markets, the issue of a price list showing what the society has to offer and stating "hard" prices may be a necessity. Where members are fairly loyal, or goodwill with non-members has been established, the issue of a price list may be a convenience. But complete reliance, even in these cases, should not be placed on the circulation of the lists. The salesman should make every effort to maintain personal contact with possible buyers. There is always the danger that the printing of a list may stereotype sales, and restrict the development of the business by leading buyers to take the goods offered on the list, but to go elsewhere for other, possibly new, requirements which are not quoted. And there is the far greater danger that the prospective buyer may use the society's price list as a lever to reduce the prices of competitors without going to the depôt, or approaching the manager, and thus giving the society the opportunity of taking the business. Carefully used, the price list may be a definite aid in selling, but it should never be expected to take the place of personal contact between the salesman and prospective buyer. While it tells the buyer what the society has to offer, it never tells the salesman what the customers of the society are thinking and feeling. Moreover, some price lists suffer from the defect of making, as regards individual recipients, indiscriminate offers, and if printed in one type, with the same or much the same offers at all seasons of the year, may be merely neglected. It may be necessary for the convenience of the whole clientèle of the society that all the goods stocked should be mentioned in its price lists, but while this is the case offers specially suited to seasonal requirements may be printed in a distinctive type at their more appropriate seasons; or new or special offers may be printed in a separate category. Perhaps a better way would be to issue supplementary or special lists for special offers at particular seasons of the year. But by some such means the price lists should be made to indicate certain goods as worthy of

special consideration and to convey definite suggestions to the minds of possible buyers. The loyal members, buyers with urgent needs or initiative, can then be trusted to look in the general list for the goods they require.

Suggestion and Persuasion.

The part played by suggestion in the selling of goods should be specially considered by every salesman. Suggestion is described as " a process by which an individual's beliefs, ideas, opinions may be directed, modified or controlled, independent of logical or rational grounds, in such a way that the individual will act on the suggested ideas or beliefs with as much certainty as he would on beliefs and opinions for which he has logical grounds ". But two of the ordinary meanings of the term convey the idea quite simply, viz., " a hint, a first intimation or proposal ", and " the presentation of an idea to the mind ".[10] The salesman rarely has sufficient time for logical processes and reasoning to conclusions and even the buyer often has not time for these in his contact with the seller, although they may proceed both before and after the selling encounter. The salesman must make his proposals acceptable, his offers effective. He has to do this in varying ways with different individuals. With one a clear, bold statement may be necessary, with others a hint or a query may be the best approach. Men differ in their sensitiveness to the opinions of others and in their susceptibility to personal or social influences in the determination of their conduct. Some, perhaps only a minority, can be influenced only be indirect suggestion because they resent any attempt to influence them by anything other than facts—as they see them—and by intellectual processes; and because they are apt to think or do the opposite to the act suggested when they suspect any attempt to influence them by other means. Indirect suggestion is an attempt to create a mental background which will give rise to the idea intended, in such a way that the individual to whom the suggestion is to be made

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[10] In practice to " suggest " is to " prompt ", or to " put an idea into one's head " to believe something or to follow a particular line of action. Insinuation, or mild insinuation (in the sense of gently gaining favour rather than of slyly hinting) is a practical part of suggestion. The effect of suggestion is measured by the acceptance of the suggested idea by the subject—the way in which or the degree to which he " takes it into his head " and acts on it. Three elements in effective suggestion are (1) Repetition; (2) Confidence—use of a confident manner or tone of voice; (3) Prestige. In dealing with an individual over a continuous but short space of time, repetition should be of *ideas* rather than *form of words*. The latter may be the more effective in dealing with an individual on more than one occasion. Some remarks on confidence and prestige are made above (p. 58).

eventually thinks the intended idea or belief is his own.[11] Thus it may be useful on occasions to tell an individual that a neighbour is buying certain goods without asking him to buy them, because he may resent the idea that he should follow the lead of another. The impression or train of thought may then be followed up on a future occasion without reference to the neighbour.[12] But by some form of suggestion the salesman does the greater part of his work, and the man who has only one method of approach to prospective buyers cannot expect to succeed with a mixed group of human beings.

"Humouring a Buyer."

Most experienced salesmen know that it is necessary to be able to feel with their buyers, or as they say " to humour them "; and sympathy, not pity, but feeling with the possible buyer, is an important element in selling capacity. On the other side, it is necessary that the salesman should have some capacity for making his customers feel with him; that he should be able to convey his own confidence and enthusiasm. The man who cannot show some sympathy with his customers' feelings or thoughts until a serious complaint is made may have to work hard in other ways, or cut his prices, to keep his customers, and he who cannot convey confidence or enthusiasm cannot expect to be successful with new clients.

Sympathy and the power of suggestion are strong elements in personal influence, and it is on the personal characteristics of the salesman, as seen by the buyer, as well as on the quality and price of goods, that successful salesmanship depends. Selling and buying is a human process, one which cannot be reduced to arithmetical terms of quality and price of goods, and the salesman who expects his customers to take all initiative or he who fails to make use of all his human powers will almost inevitably give place to one who is more active and who will consider his customers, their desires as well as their needs, and, above all, their personal characteristics. " Business ", it is said, " is primarily the study of human nature ", and though the co-operative movement assumes something of intelligence, honesty, and of mutual interest in human beings which is not always assumed in other types of business organisation, the efficient salesman will not assume these to be the sole characteristics of his clients.

11 The effect of one type of suggestion may be that of setting up a train of thought—of " giving a loose to the fancy " or " setting wits to work ". If it is desired to introduce a new article or to lead a customer to strike out to something new, this form may be particularly valuable in the first instance.

12 Acceptance of an idea—as of the usefulness of an article—is not sufficient result in salesmanship. Action must follow belief, and one suggestion may have to be followed by another.

The Goods Offered.

The goods may be subject to quite dispassionate (or unfeeling) valuation by one party or the other or by both acting separately, but will not necessarily be subject to two unfeeling valuations. There are some cases in which valuation by the prospective buyer may be made before the article is seen, or before the selling encounter begins, as with standard articles and standard services. There are many other cases in which valuation does not begin until the article is seen and the selling encounter is starting. But there are many valuations, even of requisites for production, into which feelings enter; and desire may be increased or diminished by the statements, bearing or actions of the prospective seller. The great factors in the determination of the result of the encounter will then be the persuasiveness of the seller, and the suggestibility of the buyer, together with their more or less rational valuations of the article.

The needs or desires of prospective buyers vary in their character and intensity. Some, as in the first type of buyer described above, may be based on accurate knowledge or decided opinions—that is, based on judgments of means to ends derived from the farmers' knowledge or experience. Others arise out of customs or habits of managing a farm, with very little element of a thought-process in their development. Still others arise from special needs of which previous knowledge or experience gives little guidance in choosing means to ends. On occasions there are desires created by a feeling towards " being in a movement " or " a fashion "; and sometimes to experiment or " try out a new thing ". Some desires also arise from suggestions or ideas that have been conveyed in conversation with other people, by lectures, by reading or similar channels.

While these needs or desires may not be entirely rational in character—the result of thought processes and deliberate choice—the judgment of satisfaction is more apt to be rational in character though it is not universally of that nature. Therefore it is desirable to meet the needs with the article which is most likely to satisfy the later judgment rather than the immediate desire. While the immediate desire must be met, the original idea of the prospective buyer of the article which will meet his need may be modified by the reasoning or suggestion[13] of the prospective seller.

There are cases in which a prospective buyer has in mind more than one article which may meet his need and others in

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[13] See also above, p. 61.

which he has in mind different qualities of one article which may do so. Thus of two farmers who may want " cake " for feeding milking cows one may go away from market as the purchaser of " feeding cake " and the other as purchaser of a " dairy cake ", according to the articles offered them by persuasive sellers or according to their different judgments or characters. Two farmers may require phosphatic fertiliser but one may buy superphosphate and the other slag, and the difference will not necessarily be determined by variations in requirements or even in prices.

But the difference between the choice of alternative articles and that between different qualities of one article is frequently only one of degree, and as the choice between varying qualities of one article offers the simpler considerations discussion may be limited to this.

As regards the particular sample of one article which is the subject of a possible transaction it must be remembered that it may have qualities which are real but not apparent, while it may have or lack others which are necessary to make an appeal to the possible buyer. It may also have others which, far from appealing to him, may upset his susceptibilities with regard to this article. The well-informed or rational buyer may judge the sample of the article by its real qualities, known or recognised, stated or guaranteed. The less well-informed or prejudiced buyer may pay more attention to some outward manifestation of supposed character or quality—of appearance, smell or texture—which appeals more to his prejudices than the real qualities as stated or known. Though there may be many degrees of information, of rational judgements of means to ends, and of prejudice, only a minority of prospective buyers will judge quality on thorough-going rational lines; and even the best informed and most rational may, and frequently does, use the lack of characteristics which are commonly or frequently said to indicate quality to depreciate the value of the particular sample in the mind of the possible seller. Or he may use the existence of characteristics commonly supposed to indicate lack of quality in the same way. In the meeting of the minds of the prospective seller and buyer prejudices as well as real knowledge or rational judgment may always be operative, sometimes only in one sometimes in both, and in greater or less degree in either. Often the existence or use of prejudice is conscious in one of the parties, but if conscious in both it may be discounted, for in the end rational judgments will prevail. But there is always the possibility that one of the parties —usually the seller—may so use suggestion in regard to prejudice

that ideas become accepted by the other and the latent rational judgment superseded by the suggestion.

Price Fixing.

The quality of a sample which is offered—whether the real quality as judged as means to an end or the appearance of quality which merely appeals to a prospective buyer—cannot be divorced from the price quoted by the trying seller to the prospective buyer, or that offered to the prospective seller by the trying buyer.

On the part of the seller there may be a policy of stating hard prices[14] for known or stated quality with a " take it or leave it " attitude, but in such cases certain conditions must exist if general selling is to occur. The quality and/or price must be eminently attractive to buyers in comparison with terms obtainable elsewhere for the same article or a substitute; personal pressure of prospective sellers must be weak; or certain other conditions must prevail which put the seller in a strong and the buyer in a weak position. As regards such conditions as last mentioned, the most common in connection with the trade of co-operative societies are the existence of habit or strong loyalty in members, pressure of membership opinion or mental coercion of some kind; or the existence of prejudice against possible competitors, or fear of their activities, which is not necessarily or directly related to possible buying and selling of a particular article. There are, of course, cases in which possible buyers are not economically free agents because of debts or similar reasons, but we are concerned only with transactions in which one party is free to buy and the other free to sell without consequences other than those of profit and loss (or satisfactions and dissatisfactions) which may arise from the particular transaction. For any article, or its various grades or qualities, there are always maximum prices beyond which the prospective buyer will not buy and minimum prices below which the prospective seller will not sell. These are fixed mainly by economic forces, but the actual price at

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14 Among the societies selling requisites there are several ways of fixing prices. They may be fixed on the " cost-plus " basis, viz., purchase price plus estimated cost of distribution, with possibly a small margin for formation of a reserve; on a " market price " basis; or on " cut " or " slightly cut " prices, i.e., below prevailing local market prices. The advantages and disadvantages of these methods deserves fuller discussion than is possible here.

As regards administration: The committee may fix a general price policy and leave the manager to adapt it to circumstances, or may fix a general policy and require adherence to it except after reference to themselves; or they may leave the manager to fix a price policy and to enjoy considerable latitude in the application of it.

which the transaction is made is largely fixed by the feelings and judgments of the two persons concerned.

Selling Suitable Goods.

For a large proportion of buyers immediate values—even of raw materials or implements—are largely mental. Often the real values of such goods can only be judged by results and frequently there is, in common parlance, " room for difference of opinion " as regards these results. Some raw materials are not used alone, use takes a part with other things in a complex causation, and accounting for results is not a simple matter. In some cases purchase and its results are separated by time and experience is not kept vividly in mind; and in any case habits and prejudices are often too strong to be broken by a little experience and its resulting thought. Hence even experience does not always bring entire rationality. It may be doubted whether the most complete organisation of education or of information would ever bring entire rationality in such matters, for not all individuals would judge results by the same standards, because differing individuals need differing satisfactions.

The honest co-operative salesman must try to fit supplies to the needs of his customers and provide real values as judged by results, but he can only do this slowly and as a process of education unless he is a man commanding confidence who by suggestion can overcome the habits or prejudice of prospective buyers. The wise salesman who has not himself claims to authority on particular goods often uses, in his suggestions to prospective buyers, the support of the judgment or practice of other people who command respect. If he has a new or a better article to sell than one previously supplied, his statements are frequently like this : " Mr. So-and-So has a good herd of cows and sells a lot of milk; he is using this ". The authority or example quoted must always be one recognised by the person to be influenced. But if the salesman cannot claim authority or obtain support in some such way in influencing a prospective buyer and thus effect a sale of the most efficient article, it is best to provide the buyer with what he wants. Even the co-operative salesman must take things as he finds them in an imperfect world and when he cannot easily persuade people to buy what they need, must sell them what they desire. There is always the danger that the person who tries too much to persuade other people to take what they need—even on the best information—rather than what they desire, may lose their confidence and then become a subject of suspicion or even derision and this must be

avoided at all costs. It is of disservice even to its own object and must be a cause of loss to the society. On the other hand, a salesman should never try to sell goods merely because he has them in stock and against his own judgment and that of the prospective buyer as to the latter's needs. He should especially avoid trying to sell such goods to the type of buyer who has good knowledge or decided opinions as regards his needs.

In the process of rendering service in the adaptation of means to ends in co-operative selling—as in selling a good or appropriate cake or a suitable and effective fertiliser for known purposes—the suggestions conveyed from the existence or actions of representatives of the society other than the manager or the salesman are very important. If it is known by prospective buyers that the "good farmers" are members of the society and especially of its committee, and that they obtain their requisites from the society, the task of the salesman will be easier than it otherwise might be. The process of convincing the possible buyer may be one of impressing him with the actions or the success of other members or customers of the society. The possible buyer may be consciously or unconsciously influenced by the suggestion, or by a desire in himself for imitation. Although farmers are less influenced by "fashion" than some other groups of people, many of them are subject to a strong innate tendency to imitation. "Looking over the hedge", so often quoted as the way farmers convince themselves of the success or desirability of new methods is not necessarily the way by which they reach rational conclusions of desirability or success, but may be the way in which they receive suggestions from other people whom they know and in whom they have confidence. Following examples seen "over the hedge" may be mere imitation. In any case, the copying of useful and satisfying variations in the ideas or methods of individuals is one of the most fruitful methods of making progress in the economic sphere.

The Society and the Buyer.

But the existence of the society affects the processes of selling and buying between the salesman and the member or prospective purchaser in more general ways; and in co-operative selling the psychological conditions may be quite different from those in which individual traders deal with individual farmers. If "co-operation" happens to be under a stigma, or co-operators are suspect as having political objectives, of being moral enthusiasts or idealists, the task of the salesman with non-members will be more difficult. His articles may be good and his prices suitable,

but there may be suspicion, fear, or doubt to combat which have nothing to do with the goods subject to offers. On the other hand, his task may be the easier with members than that of the ordinary salesman with the ordinary buyer whenever there is unity and a strong feeling of attachment between members and the society. But as salesmen have realised, the existence of disagreement between members and the management committee as regards the policy of the society, or the existence of factions within the society, may make his task with members more difficult than that of the ordinary trader. Differences of opinion with regard to the policy of distributing profits or building up of financial reserves have been known to affect the task of the salesman. Perhaps somewhat similar conditions arise when agents of other organisations or firms deal with farmers, except that they are rarely suspected of political or moral enthusiasm. But often in these cases the firms are remote and impersonal, the sole personality present to the mind of the prospective buyer at the time of the transaction being the personal representative of the firm. While the firm is in the background as an abstract entity the feelings of the farmer favourable or unfavourable to a possible transaction are not directly affected by it to the same extent as they may be, and are frequently, by the existence of the co-operative society and of some individual person or persons connected with it. The farmer may be influenced by the reputation of a firm, or possibly by its advertisements, but feelings aroused are not usually so keen as in the case of the more clearly or constantly realised co-operative society. Hence it is not only necessary that a society should support its salesmen, but that those who control its policy and activities should do whatever is possible to keep the society in good repute with members or prospective purchasers. There are, of course, cases in which the manager (or some other official) is of more importance than the " society "—where the business is a " one-man show "—where his capacity as a salesman is the main feature of the organisation, but in such cases there is little co-operation. On the other hand, there are societies which have such a good reputation with members and customers that they always offer their societies the opportunity of taking their business and the salesmen's main object is to provide satisfactory goods at fair prices. This is the best condition for co-operative selling, but many societies have not succeeded in attaining to it.

The Society and the Salesman.

Some of the relationships between the manager or salesman and the society itself may also have a considerable influence on

the possibilities of sales. The salesman himself may be a party to the disagreements or factions which have been mentioned, but if he is concerned with the business rather than the policy of the society, holding himself apart, as far as possible, from matters of policy which are likely to have an adverse influence on the sales, some other conditions are worthy of consideration. The amount and method of payment of earnings of the salesmen may affect results, not only through their influence on the activities of the salesman himself but also through their effect on the thought of possible buyers. Farmer co-operators have a prejudice in favour of cheap managers or salesmen, but they also have respect for a man who demands a fair salary for his services and succeeds in obtaining it. This respect can often be turned into business confidence. There are cases in which efficient managers are obtained very cheaply and in which something like affection is established between the manager and the more active members of the society, and where the fact that the manager is partly "giving" services engenders some feeling of loyalty; but gratitude is not to be expected too frequently in any form of public organisation and such a manager does not always inspire confidence in the more suspicious or "hard-headed" members or prospective buyers. While his honesty may not be suspect his business capacity is sometimes doubted. And it is good for a salesman to have the reputation for business capacity, even as regards his own affairs. The method of payment, as well as the amount of salary, also has some influence on the thought of certain buyers. After looking through the bins in a farmer's feeding shed an Agricultural Organiser recently said to the farmer, "I wish I could sell you information about rations for cows as easily as that travelling salesman sells you dud feeding stuffs." "Ah," replied the farmer, "but you don't have to get a living by it." The Organiser and the farmer were on good terms with each other and it was not any lack of efficiency or activity in the former to which the latter referred, but rather to his own thought, and to his greater feeling of community with the man of uncertain earnings than with the salaried person. There can be little doubt that many farmers have more community of feeling with the independent trader than with "the man who gets his money every month." They will frequently give their orders to "help a man to get on," or to "help a trying fellow," without close consideration of other matters connected with the business. Thus it sometimes assists a salesman, not only in the stimulus to his own activities but in his relations with buyers, if his earnings are to some extent directly

dependent on his sales.[15] It may perhaps be said that farmers would realise the dependence of the salesman's position and earnings upon his efficiency; but this is not always recognised, and even when questioned in regard to their attitude they will sometimes suggest that the fact is otherwise or that the interval between cause and effect is too long. In any case, anything that will create community of feeling between the salesman and the prospective buyer and any system which enables the salesman to command business respect and confidence is to his advantage as a seller. While farmers are sometimes prejudiced in favour of cheap employees a strong tendency to respect superiority in regard to things within their own local or business spheres is common amongst them.

Success in co-operative selling is dependent upon such ideas and conditions. While the object of every society must be that of supplying the best or most suitable goods at such prices as will enable its members to find advantage in trading with it, either in immediate price or in trade dividend, only a few societies are in a position which enables them to depend on these principles alone for the increase of their trade. No society can exist and develop on the art of enthusing or manipulating human nature; but the representatives of struggling societies must go in search of customers, and in extending their activities they must use all the fair and effective arts of salesmanship.

FERTILITY AND SEX-RATIO IN WELSH MOUNTAIN SHEEP WITH SPECIAL REFERENCE TO THE EFFECTS OF ENVIRONMENT.

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1. Introduction.

Fertility in sheep has been the subject of several statistical and physiological investigations and these have brought to light

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[15] The methods of payment of managers or salesmen are " by salary ", " by commission ", " by salary plus commission ", or " by salary plus bonus ". There are, perhaps, other considerations in respect of methods of payment, but I have dealt with them only as affecting sales.

the various effects of such factors as breed differences, the condition of ewes at tupping time ("flushing"), crossbred versus purebred matings, the age of the ewes, etc. The relationship of fertility to barrenness and abortion on the one hand, and to twinning on the other, has also been carefully investigated. Rather fewer and less detailed investigations have been carried out with reference to the sex-ratio.

The statistical data collected have referred almost entirely to lowland breeds; for example, Heape (1899), dealing with returns of over 120,000 sheep, includes practically no mountain breeds, and in particular one aspect of the breeding of mountain sheep remains a virgin field, *viz.*, the large differences in fertility between sheep kept under mountain conditions and precisely similar sheep drafted to the low ground.

During the season 1922-1923 a questionnaire was circulated to breeders of Welsh Mountain sheep by the University College of North Wales, breeders being asked to state in particular the type of land on which their flocks were kept, the number of ewes in the flock, the number of ram and of ewe lambs born, and the number of barren ewes. It will be readily appreciated that the difficulties involved in this survey were very much greater than those involved in the collection of data from purely lowland flocks. In lowland flocks the owner can often give a complete statement accounting for every ewe, but this is hardly possible under mountain conditions. In particular, if sheep are lambed on the mountain, lambs which are still-born or which die very soon after birth will often not be found and their mothers will simply be included in the "barrens," as a complete return will in many cases not be made until the time of castrating the ram lambs. This will be the earliest time, too, at which the sex-ratio can be determined, so that lambs which die before this period may or may not be included. In the writing up of the results of this investigation these difficulties have been constantly borne in mind, so that undue importance should not be attached to conclusions which are supported by insufficient data or which are rendered doubtful owing to a lack of precision in the data. At the time at which the original questionnaire was circulated the chief object in view was the collection of data on the sex-ratio, as it was thought that it would be useful to test the belief often expressed by breeders that this varies considerably in response to seasonal changes. It was soon apparent, however, that the figures dealing with fertility were likely to be of greater interest, so for the season 1923-1924 an improved questionnaire was drawn up which permitted a much more accurate analysis of fertility.

The first step which marks the particular interest of these results was to classify the returns according to the type of land on which the flocks were kept. This was done partly from the information supplied by the flock-owners and partly from general knowledge of the districts. The writers wish to acknowledge the valuable assistance of Mr. R. N. Jones in this task. Three classes were selected, and in classifying the flocks the following distinctions were adopted :—

(1) *Mountain.* Flocks were placed in this class if kept during the summer on unenclosed uncultivable land of such poor quality and great elevation that no ewe lambs and few ewes are wintered there. In such cases the majority of the ewes are usually wintered either on lower hill land or as " tack " sheep on lowland.

(2) *Intermediate.* Flocks kept for the greater part of the year on upland grazings uncultivable under present conditions and varying in height from, say, 500-1,500 feet.

(3) *Lowland.* Flocks kept all the year round on enclosed cultivable (not necessarily recently cultivated) land; 1,000 feet would be the extreme limit, but 400-500 feet would be the usual limit.

It is important to note that the data refer solely to Welsh Mountain ewes served by Welsh Mountain rams; particulars relating to crosses or to any other breed are not included.

2. Fertility.

In considering fertility five figures are desirable for each flock :—

(*a*) The number of lambs born per 100 ewes, this figure including still-births.

(*b*) The percentage of barren ewes. In the case of mountain flocks it is quite impossible to separate barrenness and abortion, so that these must be considered together.

(*c*) The percentage of ewes producing twins.

(*d*) The percentage of lambs which are still-born or which die before an arbitrarily fixed time, say castration.

(*e*) The number of lambs per 100 ewes at the time of castration.

It will be noticed that $a = 100 - b + c$, and $e = a - d$.

The majority of returns of 1923-1924 give b, d, and e with considerable accuracy and from these have been calculated a and c. The returns of 1922-1923 are not so satisfactory. Owners

were asked to give the number of lambs born, including still-births and deaths before the date on which the return was made, and also the number of barren ewes. It is obvious, however, that this was done in some cases only, so that the returns are only used to obtain the quantity which is the most important. The value obtained is undoubtedly too low as regards the Mountain and Intermediate classes.

TABLE I.

1922-1923.

Flock.	Lambs per 100 ewes (*a*).			*Lambs per 100 ewes.*
	No. of flocks.	*No. of ewes.*	*No. of lambs.*	
Mountain ...	37	7,529	6,809	90.4
Intermediate ...	19	2,931	2,762	94.2
Lowland ...	24	1,561	1,925	123.3

TABLE II.

1923-1924.

	Mountain.	*Intermediate.*	*Lowland.*
Quantity (*a*)			
No. of flocks ...	23	12	10
No. of ewes ..	3,680	1,428	682
Lambs born per 100 ewes ...	97.8	99.7	128.0
Quantity (*b*)			
No. of ewes ...	3,202	1,057	618
Percentage barrenness	5.1	2.8	2.4
Quantity (*c*)			
No. of ewes ...	2,752	1,057	618
Percentage ewes producing twins ...	1.7	6.0	32.0
Quantity (*d*)			
Percentage still-births and deaths ...	10.7	6.3	3.6
Quantity (*e*)			
No. of ewes ...	3,680	1,428	682
Lambs per 100 ewes at time of castration ...	87.1	93.4	124.4

It will be noted that in Table II the total number of ewes is not the same in the calculation of the five quantities. This is due to the fact that some incomplete returns could be used

for one purpose but not for all. As a result, the various quantities do not quite agree in all cases. The figures for lambs born per 100 ewes in 1923 are undoubtedly too low in the case of Mountain and Intermediate classes, the reason being that the returns included some but not all of the still-births and lambs that died soon after birth. No attempt has therefore been made to compare the figures for the two seasons.

The figure that concerns the breeder is the number of lambs reared which will not be far from the quantity *e*, the number of living lambs at about the time of castration. The big variations between the results from flocks of the three types are caused by three factors :—

1. The percentage of ewes which either do not conceive or which abort.
2. The percentage of twinning.
3. The percentage of still-births and deaths.

Smoothing out the figures for 1923-1924, the results indicate the following situation :—

TABLE III.

	Percentage Barrenness.	*Percentage Twinning.*	*Percentage Lambs born.*	*Percentage still-births and deaths.*	*Percentage Lambs at Castration.*
Mountain	5	2	97	11	86
Intermediate	3	6	103	6	97
Lowland	2	32	130	4	126

Comparing Mountain and Lowland, the relative importance of barrenness, twinning, and deaths in their effect on fertility are 7.5 per cent., 75.0 per cent., and 17.5 per cent.; it is interesting to observe that in the matter of twinning the Intermediate class tends to follow the Mountain class, while as regards barrenness and deaths it tends to follow the Lowland class.

It remains to analyse the possible deeper causes underlying barrenness, twinning and deaths at or after birth. This is rendered possible by the work of Heape (1899), Marshall (1904, 1905, 1908 and 1909), Hammond (1914 and 1921), Corner (1923) and Nichols (1924 and 1926). It has been shown that a limiting factor in fertility is the number of ova extruded from the ovaries at each œstrous period and upon this will depend the proportion of twins. The number of ova shed is in turn affected by the

condition of the ewes at the time of tupping and the date of the tupping season and the proportion of rams to ewes (ensuring that each ewe is served the first time it comes on heat) in particular. The practice of flushing is known to produce an increase in the percentage of twins. The big difference between Lowland and Mountain flocks as regards twinning is probably due then to the fact that the condition of the Mountain ewes is such that single ova are the rule at each œstrous period. The late date of tupping may also produce some effect. It is possible that some reduction in the number of twins is brought about by fœtal atrophy, *i.e.*, the death of one of the two fœtuses during the course of pregnancy, but this is not likely to be a serious factor.

Barrenness has been shown to be associated to some extent in a negative sense with twinning, so that those influences which tend to depress twinning may also tend to raise the proportion of barren ewes. Barrenness in this paper includes abortion, so that if fœtal atrophy were more prevalent in the case of the Mountain class this would account for part of the increase in barrenness. This is possible, as Hammond (1921) considers that fœtal atrophy may be in part nutritional. It may be argued that the figure 5.1 per cent. for the Mountain class is a little too low, and it is perhaps possible that the returns include too small a proportion of flocks kept under the most severe conditions. In a well managed flock it should not be the case that ewes miss getting served, but if this were to occur the percentage of barrenness might rise considerably. Still-births and deaths before the time of castration depend upon the condition of the ewes at lambing time, the place where they are lambed, and the care expended on them, and of these factors it is suggested that the first is the most important.

To sum up the practical aspects of the conclusions that appear to emerge from the present work, it is probable that special treatment at the two extremes of the season would produce the greatest effect in raising the fertility of mountain flocks. Tupping the sheep on the low ground might increase the percentage of twins and reduce barrenness slightly but would present difficulties, because first the ewes would have to be brought into specially good condition, and secondly the beneficial effect might be lost if they were not tupped earlier, and this would seldom be possible or desirable. Moreover, mountain farmers do not want many twins. A few to replace lambs which have died from one cause or another are all that are required. At the other end of the season special care at lambing time should reduce the number

of still-births and deaths, but it is doubtful whether bringing the ewes to low ground immediately before lambing would be nearly so effective as bringing them down rather earlier so as to get them into good condition. Young ewes in poor condition at lambing time have very little milk and their lambs have a poor chance in a bad season, even if the ewes do not leave them before they have got on to their legs.

3. The Sex-Ratio.

A sex-ratio may be expressed as the number of males per 100 females or as the percentage of males. Primary and secondary sex-ratios are to be distinguished. The primary sex-ratio is that at conception and can usually only be estimated approximately. The secondary sex-ratio is that existing at birth and is held to differ from the primary sex-ratio because prenatal death bears more heavily on the males. In this paper it is the secondary sex-ratio which will be considered.

TABLE IV.

	Ram Lambs born.	*Ewe Lambs born.*	*Males per 100 females.*
	1922—23.		
Mountain ...	3,328	3,514	94.7
Intermediate ...	1,286	1,430	89.9
Lowland ...	963	971	99.2
Total ...	5,577	5,915	94.3
	1923—24.		
Mountain ...	1,943	1,965	98.9
Intermediate ...	606	694	87.3
Lowland ...	395	471	83.9
Total ...	2,944	3,180	94.1
	Both years.		
Mountain ...	5,271	5,479	96.2
Intermediate ...	1,892	2,124	89.1
Lowland ...	1,358	1,442	94.2
Total ...	8,521	9,045	94.2

In the 1923-1924 returns under the heading still-born lambs and those which died, 199 males and 173 females were returned, giving a sex-ratio in this class of 115.0. The true secondary sex-ratio is probably a little higher in each case than the figures quoted, especially in 1923, but the effect is not great with a sex-ratio of dead lambs so near equality. It might have been expected that the proportion of males would fall from Lowland through Intermediate to Mountain owing to heavier prenatal

mortality killing off more males, but this does not appear to be the case. The numbers, however, are small and the fact that the Intermediate class does not lie between the other two in any case disposes one to assume that nothing is to be learnt as far as these returns go regarding any effect of the type of grazing on the sex-ratio.

The total sex-ratio for the two seasons is almost the same, but many more results would be required and observations extending over many seasons before it would be possible to state anything with reference to a general effect of season on the sex-ratio.

The total sex-ratio is 94.2, which is rather lower than the generally accepted figure for sheep of 97.5 (Heape, 97.4; Doncaster and others, 99.7; Nichols, 97.4 and 100). It is interesting that Nichols (1924) gives the sex-ratio for Blackfaces as 94.5. The sex-ratio 115.0 for still-births and deaths is low and does not indicate at all a severely selective mortality affecting the males.

A further question can be investigated in the returns. Individual flocks give widely differing sex-ratios and it would be of interest to know whether influences such as the individuality of flocks or the nature of local conditions tend to give special sex-ratios. It is possible to test whether the flocks considered appear to be a homogenous population or not, *i.e.*, is the variability to be ascribed to chance. Working out the percentage males in each flock and neglecting flocks when the number of lambs is less than 50, the mean percentage of males is 48.5. The flock percentages should be distributed in the binomial $(0.515 + 0.485)^{100}$ if the material is homogenous. Using the χ^2 distribution

$$\chi^2 = 86.2$$
$$n = 95.$$
$$\sqrt{2\chi^2} - \sqrt{2n - 1} = -0.62$$

It can be stated therefore that there is no reason to suppose that the deviations from the mean value in the various flocks are not due to chance.

In the case of twenty flocks comparable records were available for both seasons. The correlation co-efficient of the sex-ratios for the two seasons was + 0.15, which is far below the level of significance, so that there was no tendency in these flocks for the sex-ratio of 1923-4 to follow that of 1922-3.

While the general conclusions of these studies on the sex-ratio are almost purely negative, it cannot be stated that it is impossible for effects to occur such as those claimed by some

breeders. Large numbers would, however, be needed to establish such a conclusion and it is unlikely that, if any such effects occur, they can do so on any large scale.

4. Summary.

1. A questionnaire was circulated to breeders of Welsh Mountain sheep during the seasons 1922-3 and 1923-4. The information required referred to fertility and to the sex-ratio. Only Welsh Mountain ewes mated with Welsh Mountain rams were considered.

2. The various flocks were classified as being kept under Mountain, Intermediate or Lowland conditions.

3. The difference in fertility between Lowland and Mountain flocks of the same breed depends on three main factors :—

- (*a*) The percentage twinning, depending principally on
  - (1) The condition of ewes at tupping time.
  - (2) Date of tupping.
- (*b*) Percentage barrenness, depending principally on
  - (1) The same factors as (*a*).
  - (2) Possibly the nature of the sheep walk and the activity of the rams.
  - (3) Fœtal atrophy during the course of pregnancy.
- (*c*) Percentage still-births and deaths soon after birth, depending principally on
  - (1) Condition of ewes at lambing time.
  - (2) Place of lambing.
  - (3) Care at lambing time and after.

Of these three factors (*a*) and (b) produce the greatest effect, and (*c*) is the more important economically.

4. The differences in the sex-ratio between the three classes of flocks and in the two seasons are not sufficiently large or regular to warrant any conclusion.

5. There is no reason to suppose, as far as the present data go, that the fluctuations in sex-ratio in different flocks are not the result of chance.

6. There was no tendency for the sex-ratio of 1923-4 to approximate to that of 1922-3 in the same flocks.

The writers wish to express their gratitude to the breeders who co-operated by sending in returns.

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A COMPARISON OF WELSH AND SHORTHORN CATTLE AS MILK PRODUCERS.

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The cattle in the four northern counties of Wales are roughly divided by the river Conway into two breeds. In Anglesey and Caernarvonshire the Welsh cattle chiefly predominate; in Denbighshire and Flintshire the dual purpose type of non-pedigree Shorthorns is almost universal, though in recent years the Welsh cattle have tended to re-establish themselves in parts of these two counties.

The College, serving as it does all four counties, has made it its policy to build up herds of both breeds at the College Farm, and since 1918 the breeds have been kept in about equal numbers, —something like twenty cows and thirty young cattle of each breed. The management of the two breeds has always been exactly the same. Practically all the heifer calves are reared and very few cattle purchased. Owing to the large flock of mountain sheep and the comparatively limited area of low ground

no bullocks are reared, and hardly any fattening is practised. The calves are all reared "on the bucket" and the yearling heifers of both breeds are grazed during the summer on the enclosed hill land. Equal care in building up the herds and in selecting the bulls has always been taken, and, with both breeds, the dual purpose type of animal has been aimed at. Daily records of the milk have been kept from the commencement.

Although it is difficult to imagine conditions in which a fairer comparison of the two breeds could be made, it is necessary to point out a possible cause of error. If, as appears to be the case, there is an appreciable difference between the two breeds as regards resistance to adverse climate and ability to thrive on inferior food, the conditions at one farm if suitable for the Shorthorns do not give the Welsh cattle a fair opportunity of displaying their special qualities of hardiness, while, on the other hand, if a farm is suited to the Welsh cattle, conditions may be so severe that the Shorthorns do not get a fair chance. Probably, however, in the special circumstances of the College Farm, this objection does not seriously detract from the value of the comparison.

The farm is situated near the border-line of the two breeds and the conditions are in some ways better than on the average Anglesey and Caernarvonshire farm. In a recent paper[1] the writer utilised the records from the College Farm to compare certain aspects of the milk production of the two breeds, and as that paper may not reach many who are interested in the subject the main conclusions may be summarised before giving the special comparison which is the purpose of this paper.

1. Taking the normal lactations, which were defined as being those in which the interval between calvings was not more than fifteen months, and in which the lactation was not affected by illness or other abnormal occurrences, the difference between the average yield of the Welsh and of the Shorthorn cows was not significant. The average yield of 118 Welsh lactations was 5,780 $\pm$ 122lb. and the average yield of 114 Shorthorn lactations was 5,513 $\pm$ 99lb. The difference in favour of the Welsh was 267lb. per lactation, but as the probable error was $\pm$ 172lb. no significance can be attached to this difference.

2. There is a distinct difference between the lactation curves of the two breeds. The Shorthorn cattle gave a higher yield than the Welsh for the first ten weeks after calving, but after this period the Welsh cows overtook them and maintained their

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[1] *Journal of Agricultural Science*, July, 1926.

superiority to the end of the lactation period. The popular idea that the Shorthorns are the better milkers of the two is undoubtedly largely due to this difference in the form of the lactation curve. Even the most experienced dairymen are likely to be too much impressed by a high maximum daily yield. It is only the men who keep milk records who can appreciate the merits of such a type of lactation as the Welsh.

3. Owing to the fact that milk is sold retail the farm has to cater for the needs of summer visitors, and an unusually large proportion (40%) of the cows of both breeds are arranged to calve about July. Such cows are not only dry when the grass is at its best in May and June, but also the lactation period is frequently abnormally short, as unless the cows are dried off at the end of April before being turned out to grass there is great difficulty in getting them dry afterwards. Thirty-seven normal lactations of Welsh cows calving in March, April and May gave an average of 6,735 ± 202lb. Forty-two normal lactations of Welsh cows calving in June, July and August gave an average of 5,435 ± 210lb. The difference in favour of the spring calvers was 1,300lb., and this is significant, as the probable error was ± 298lb. Thirty-eight normal lactations of Shorthorn cows calving in March, April and May gave an average yield of 6,059 ± 175lb. Forty-eight normal lactations of Shorthorn cows calving in June, July and August gave an average of 5,207 ± 132lb. The difference in favour of the spring calvers being 852, the probable error was ± 248lb.

The difference between the Shorthorn and the Welsh in this respect, though hardly significant, taken along with other observations suggested a possibility that the behaviour of the two breeds during the change from winter to spring conditions and *vice versa* might show important differences.

The Effect of Spring Grass on the Yield of Dairy Shorthorn and of Welsh Black Cattle.

The usual effect on the milk yield of turning cows out to grass in spring is well known, and the milk records of the cows at Aber were investigated in order to ascertain whether the two breeds showed any difference in the extent to which they responded to the effect of spring grass.

The cows are turned out to grass about the end of May, sometimes early in June. Milk records from 1918-1926 inclusive were examined, the record of every cow and heifer remaining in milk from the 1st May to the 14th June (inclusive) being included.

The number of Shorthorn lactations obtained was 154, while 143 Welsh lactations were included.

The extent of the " spring flush " was determined as follows :

(*a*) The highest two day yield in the six weeks was determined for each cow. This occurred after the cows had been turned out to grass.

(*b*) These two days and the five following days were taken as the seven days' " maximum flow."

(*c*) The lowest two day yield in the six weeks period was determined for each cow. This was while the cows were still indoors on winter rations.

(*d*) These two days, together with the five previous days, were taken as the period of " minimum yield."

The table given below gives the yield of the Welsh and of the Shorthorn cows during the periods of minimum and maximum flow in each year, together with the number of cows of both breeds included in each year. The total yields per minimum and per maximum flow periods are also given for each breed.

Thus, taking a seven day period before and during the " flush," the Shorthorns increased 21.7lb. per cow, and the Welsh 26.2lb. per cow, the increase being 4.5lb. per cow (for the seven days) greater in the Welsh than in the Shorthorns. In ascertaining the significance of this difference the probable errors have been calculated only in the case of the Welsh, since they showed the difference to be undoubtedly not significant.

Thus mean Welsh yield per period of minimum flow = 148 ± 3.21lb.

Thus mean Welsh yield per period of maximum flow = 174 ± 3.81lb.

Thus mean difference between minimum and maximum flow = 26 ± 4.98lb.

The probable error of this difference is thus greater than the difference between the Welsh and Shorthorn increase (4.5lb.). It is thus impossible to say that there has been any important differences between the response of the Welsh and the Shorthorn cows to the spring grass during the last fourteen years at the farm. The number of cows in any one year is not sufficient to enable conclusions to be drawn as to which breed responded the more quickly to the grass, or as to the effects of a favourable or unfavourable spring on the relative behaviour of the two breeds.

Shorthorn yield during				*Welsh yield during*		
No. of Cows.	*Minimum* period.*	*Maximum* period.*	*Year.*	*No. of Cows.*	*Minimum* period.*	*Maximum* period.*
	lbs.	lbs.			lbs.	lbs.
11	2,078	2,038	1926	10	1,684	1,816
8	1,473	1,571	1925	12	1,384	1,728
12	2,074	2,373	1924	10	1,599	1,853
14	2,451	2,407	1923	10	1,787	1,857
12	1,789	1,822	1922	10	1,822	1,922
10	1,631	1,899	1921	9	1,379	1,581
11	1,532	1,882	1920	12	1,651	2,062
11	1,788	2,507	1919	11	1,245	1,601
9	1,511	1,648	1918	12	1,834	2,141
11	1,700	2,100	1917	14	1,685	2,249
7	1,368	1,545	1916	16	2,479	2,835
14	2,068	2,595	1915	9	1,336	1,647
13	2,423	2,561	1914	3	541	684
8	1,872	2,157	1913	5	790	989
154	25,758	29,105	1913–26	143	21,216	24,965

Total difference between minimum and maximum periods = 3,347 lbs. or 21·7 lbs. of milk per cow for the seven days.

Total difference between minimum and maximum periods = 3,749 lbs. or 26·2 lbs. of milk per cow for the seven days.

I wish to express grateful acknowledgement to Professor R. G. White for suggesting the investigations described, and to Mr. J. A. F. Roberts for helpful suggestions in the statistical treatment.

* As noted above, the minimum period always occurred before the cows went out to grass, while the maximum period was invariably found to be on grass.

FURTHER STUDIES IN THE FORMATION OF PERMANENT PASTURES IN NORTH WALES.

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The present article is an attempt to complete a scheme of study of the intermediate phases of the establishment of permanent pastures in North Wales. It proposes to supplement a study which appeared in the last number of this Journal,[1] by bringing those centres laid down in 1921 to line with those of 1919 and 1920 and submitting an analysis of the herbage in the winter of the 4th-5th year.

Whereas it would be inadvisable to recapitulate here the detailed aims of the scheme as originally planned, and as set out in the forementioned article (*loc. cit.*), the following is a list of the centres at which the various seeds mixtures were sown and shows besides the composition of the respective mixtures used.

Centres laid down in 1921.

Anglesey :—Glasgraig, Rhosgoch, Mr. J. R. Williams.
Caernarvonshire :—College Farm (Cae Hir), Aber, U.C.N.W.
Denbighshire :—Fachell Farm, Rhuddlan, Mr. John Edwards.
Flintshire :—Pinfold Farm, Bronnington, Mr. Mottershead.
Berthymaen, Trelogan, Mr. J. E. Evans.
Plas-is-Llan, Cwm, Llanelidan, Mr. W. McLellan.

TABLE I.
Sown 1921.

		Lb. of seed per acre.					
	Plots:	A	B	C	D	E	F
Italian ryegrass	...	6	—	6	6	6	6
Perennial ryegrass	...	10	10	—	10	10	15
Cocksfoot	...	6	6	6	—	6	2
Timothy	...	3	3	3	3	3	2
Meadow fescue	...	2	2	2	2	2	—
Crested dogstail	...	1	1	1	1	—	½
Rough stalked meadow grass	...	1	1	1	1	—	—
Broad red clover	...	2	2	2	2	2	2
Late flowering red clover	...	2	2	2	2	2	2
Alsike	...	1	1	1	1	1	1
Wild white clover	...	1	1	1	1	1	1
Chicory	...	1	1	1	1	1	—
Yarrow	...	¼	¼	¼	¼	—	—
Total	...	36¼	30¼	26¼	30¼	34	31½

[1] "Some studies in the Formation of Permanent Pastures in North Wales", by R. Alun Roberts, B.Sc., University College, Bangor. *Welsh Journal of Agriculture*, Vol. II, 1926.

It was fortunately possible to continue the study of all the centres sown in 1921 through into the fourth or fifth year. With the exception of Fachell the centres offer an interesting study. The plots at this farm, which is very low-lying, have so degenerated through continued wet weather and heavy winter grazing by sheep that this fact colours our approach to it, and modifies our findings there. It affords, however, a definite study in degeneration different from the others in that the normal decline of the sward has been both accelerated and accentuated.

The plots were examined in the winter condition to afford a fair basis of comparison with the earlier series, previously examined in the winter of 1924-25. We succeeded in this with one exception.

The College Farm was examined in Dec., 1925,—Jan., 1926, followed by Glasgraig in early February, Fachell in the latter half of February, Plas-is-Llan in early March and Berthymaen in late March. Pressure of spring work, however, delayed the examination of Pinfold Farm till the end of April, by which time there was a fair flush of spring growth.

As before, twenty sample turves 12 inch by 1 inch were drawn from each plot, and after separation in the laboratory and air-drying until of uniform weight the percentage representation of each species by weight was determined.

The following tables give the analyses of the plots at the various centres. Whereas in previous analyses the sown species only were separately considered and the miscellaneous unsown species were grouped together though separately listed, in the present case the more important miscellaneous unsown species have been separately mentioned and their percentage contribution to the herbage separately determined. Having regard to the high percentage of miscellaneous and weed flora in the swards, it was felt that some profit could come by thus examining it further. To afford a basis of comparison with previous work, however, their total representation on a collective basis is also given.

Consideration of Results.

As is always the case with numerous centres variously placed over a considerably wide area, one finds again that the modifications produced from plot to plot at each centre have far more significance than minor modifications within the same plot considered from centre to centre. This was obvious each time one visited the plots. At all centres alike the sward in the fourth or fifth year falls far short of the theoretical ideal one aimed at at the start. There is a marked levelling down of the composition.

TABLE II.

Percentage Analysis of Hay in Second Season, 1923. (By Weight). Sown 1921, and Percentage Analysis of Grazed Pasture in Winter, 1925-26.

	A.												B.											
	Pinfold Farm.		*Fachell Farm.*		*Glasgraig.*		*Berth-y-Maen.*		*College Farm.*		**Plas-is-llan. (Grazed).**		*Pinfold Farm.*		*Fachell Farm.*		*Glasgraig.*		*Berth-y-Maen.*		*College Farm.*		**Plas-is-llan. (Grazed).**	
	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926
Italian Ryegrass	**4.2**	—	**1.4**	—	**3.2**	—	**8.3**	—	**2.8**	—	**3.0**	—	**.5**	—	**.9**	—	—	—	—	—	**.1**	—	**.4**	—
Perennial Ryegrass	**35.1**	5.1	**21.5**	12.8	**20.8**	3.9	**32.4**	11.5	**28.8**	8.7	**26.1**	10.9	**40.3**	10.0	**12.6**	6.6	**11.7**	2.4	**23.1**	11.6	**47.3**	9.3	**29.3**	9.9
Cocksfoot	**26.3**	6.5	**22.8**	1.5	**22.3**	4.6	**12.5**	1.9	**10.4**	.1	**3.4**	.6	**20.1**	1.8	**20.9**	.7	**32.9**	1.4	**18.5**	3.7	**15.6**	.7	**6.8**	.9
Timothy	**2.4**	.8	**.2**	—	**7.4**	Trace	**3.2**	—	**8.5**	.1	**.5**	—	**.8**	.1	**1.4**	—	**7.9**	—	**1.6**	1.1	**16.3**	.2	—	—
Meadow Fescue	**.2**	1.0	**.4**	—	**.4**	—	**.7**	—	**1.7**	.6	—	—	**.5**	1.6	—	—	**.4**	.2	**1.3**	—	**5.0**	—	—	—
Crested Dogstail	**5.4**	1.2	—	1.6	**.5**	26.3	**1.0**	11.5	**2.7**	15.6	**3.0**	2.8	**.2**	1.2	**.2**	1.5	**2.4**	38.6	**.1**	4.5	**.6**	13.3	**5.3**	2.8
Rough Stalked Meadow Grass	**7.2**	16.9	**6.2**	11.9	**6.3**	4.2	**7.4**	36.2	**6.0**	12.1	**29.7**	13.1	**5.3**	18.3	**5.0**	9.4	**9.1**	1.2	**10.0**	31.2	**2.0**	20.3	**24.7**	15.8
Broad Red Clover / Late Flowering Red Clover	**6.5**	—	**31.8**	—	**18.9**	—	**18.2**	—	**18.9**	—	**.3**	-	**7.3**	—	**25.1**	—	**21.2**	—	**19.8**	—	**17.8**	.3	**4.1**	—
Alsike	**.1**	—	**2.9**	—	**3.2**	—	**2.1**	—	**4.1**	—	—	—	**.5**	—	**10.8**	—	**3.2**	—	**4.5**	—	**1.2**	—	—	—
Wild White Clover	**9.0**	28.2	**6.2**	11.6	**10.3**	21.8	**12.0**	10.6	**12.1**	36.5	**23.8**	33.7	**10.8**	32.9	**12.0**	22.7	**5.2**	23.8	**17.3**	34.0	**10.6**	40.7	**22.1**	37.9
Chicory	**2.1**	—	**.4**	—	**.9**	—	**1.3**	—	**.6**	—	**.2**	—	**9.8**	—	**.5**	—	**.1**	—	**.2**	—	**.9**	—	—	—
Yarrow	**.5**	.8	—	—	—	—	**.1**	—	—	—	**.5**	—	—	.8	**.2**	—	**.2**	.3	**.2**	.8	**.2**	.6	**.4**	.2
Miscellaneous	**1.0**	31.7	**6.2**	60.6	**5.8**	39.2	**.8**	28.3	**3.4**	26.3	**9.5**	38.0	**3.9**	22.1	**10.4**	59.3	**5.7**	32.1	**3.4**	7.1	**2.4**	14.6	**6.9**	32.5

TABLE II. (Continued).

Percentage Analysis of Hay in Second Season, 1923. (By Weight). Sown 1921, and Percentage Analysis of Grazed Pasture in Winter, 1925-26.

C.

	Pinfold Farm.		*Fachell Farm.*		*Glasgraig.*		*Berth-y-Maen.*		*College Farm.*		Plas-is-llan. (Grazed).	
	192	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926
Italian Ryegrass	10.7	—	1.6	—	14.0	—	16.9	—	7.2	—	2.4	—
Perennial Ryegrass	11.3	—	1.2	10.2	.9	1.8	4.5	12.1	14.4	4.8	16.5	8.3
Cocksfoot	31.3	3.4	27.7	6.7	6.8	8.6	20.6	6.0	7.9	.1	2.8	.8
Timothy	2.1	Trace	1.8	—	15.6	.4	6.1	—	13.6	.1	.8	—
Meadow Fescue	.4	1.3	5.5	—	1.3	.1	1.3	—	4.2	—	—	—
Crested Dogstail	1.5	1.1	1.3	2.6	1.8	27.6	2.7	5.9	2.1	10.2	3.3	1.4
Rough Stalked Meadow Grass	7.7	13.3	3.8	24.5	11.4	5.7	11.5	26.7	5.1	13.5	9.8	18.8
Broad Red Clover / Late Flowering Red Clover	11.8	—	43.5	—	7.4	—	3.3	—	11.6	—	23.6	—
Alsike	2.5	—	1.2	—	3.5	—	4.3	—	1.6	—	3.3	—
Wild White Clover	8.8	29.5	4.8	14.9	11.5	26.8	19.1	36.6	22.9	42 6	22.9	41.0
Chicory	.4	—	3.0	—	.6	—	2.2	—	2.9	—	—	—
Yarrow	—	3.7	—	—	.4	.5	.7	—	—	—	.5	.1
Miscellaneous	10.6	43.9	4.6	41 1	4.8	28.5	6.8	12.7	6.5	28.7	14.1	16.3

D.

	Pinfold Farm.		*Fachell Farm.*		*Glasgraig.*		*Berth-y-Maen.*		*College Farm.*		Plas-is-llan. (Grazed).	
	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926
Italian Ryegrass	9.9	—	—	—	4.7	—	14.7	—	1.8	—	21.4	—
Perennial Ryegrass	43.3	6.4	12.9	3.4	22.1	5.0	24.4	16.5	37.8	11.4	7.8	8.8
Cocksfoot	.2	—	—	.5	—	—	—	—	—	—	1.8	—
Timothy	.8	.1	.8	—	13.2	.8	2.9	—	4.5	.3	2.3	—
Meadow Fescue	.3	1.7	—	—	.2	—	.1	—	2.0	—	—	—
Crested Dogstail	5.6	1.5	—	1.0	6.8	27.6	1.7	6.9	2.7	9.1	2.5	4.4
Rough Stalked Meadow Grass	5.1	11.3	4.3	25.2	7.4	2.6	5.7	21.9	2.1	15.1	6.4	17.5
Broad Red Clover	12.5	—	65.4	—	28.4	—	25.6	—	22.8	—	2.3	—
Late Flowering Red Clover	—	—	—	—	—	—	—	—	—	—	—	.4
Alsike	.9	—	1.4	—	3.0	—	.2	—	4.4	—	—	—
Wild White Clover	12.8	24.6	6.0	23.7	10.5	26.0	15.1	42.3	16.7	39.9	28.7	33.3
Chicory	.6	—	.2	—	.1	—	1.7	—	.8	—	—	—
Yarrow	.2	1.4	—	—	.2	.7	.1	—	.5	—	.6	—
Miscellaneous	7.8	50.7	9.0	46.2	3.4	37.3	7.8	12.4	3.9	21.2	26.2	35.6

TABLE II. (Continued).

Percentage Analysis of Hay in Second Season, 1923. (By Weight). Sown 1921, and Percentage Analysis of Grazed Pasture in Winter, 1925-26.

	E.												F.											
	Pinfold Farm.		*Fachell Farm.*		*Glasgraig.*		*Berth-y-Maen.*		*College Farm.*		Plas-is-llan. (Grazed).		*Pinfold Farm.*		*Fachell Farm.*		*Glasgraig.*		*Berth-y-Maen.*		*College Farm.*		Plas-is-llan. (Grazed).	
	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926	1923	1926
Italian Ryegrass	10.4	—	2.1	—	6.9	—	17.6	—	4.0	—	1.7	—	15.0	—	.2	—	11.6	—	11.8	—	7.7	—	9.0	—
Perennial Ryegrass	38.5	8.4	15.5	17.3	16.6	12.9	13.7	13.6	21.2	13.5	14.7	11.1	40.6	20.0	10.8	9.1	22.8	4.6	26.8	18.9	29.6	11.6	18.2	20.3
Cocksfoot	15.2	7.4	6.8	3.4	33.0	1.8	12.5	6.9	19.2	.2	2.5	1.7	10.7	8.5	.8	—	18.6	.1	11.8	1.9	9.2	.5	3.7	.4
Timothy	4.0	.6	.2	—	16.1	.5	.9	—	5.6	—	—	—	.2	2.8	—	—	6.3	.3	—	—	6.2	—	3.0	—
Meadow Fescue	.2	3.6	—	—	.8	—	—	—	.9	—	—	—	—	.7	—	—	—	—	—	—	.3	—	—	—
Crested Dogstail	—	.9	—	—	.1	11.8	—	1.2	—	2.2	22.5	—	.9	1.8	—	—	7.2	19.7	.5	5.7	4.9	10.0	—	.2
Rough Stalked Meadow Grass	4.1	14.1	3.7	.7	.2	.5	3.6	28.5	1.9	12.4	3.6	14.9	1.9	5.1	5.9	—	.4	.3	3.2	24.9	1.6	7.8	1.2	14.8
Broad Red Clover ... Late Flowering Red Clover	7.8	.4	60.9	—	16.9	—	23.9	—	25.2	—	—	—	16.2	—	57.5	—	15.1	—	26.7	—	17.9	—	.4	—
Alsike	1.5	—	.4	—	1.7	—	2.9	—	3.3	—	—	—	1.5	—	4.1	—	.7	—	3.9	—	5.3	—	—	—
Wild White Clover	14.0	37.6	3.3	24.3	6.3	44.2	8.7	36.3	12.7	43.0	24.3	32.7	12.6	36.3	3.7	12.1	12.3	45.3	11.5	42.4	13.2	41.3	49.2	40.6
Chicory	1.0	—	.2	—	.4	—	6.4	—	1.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Yarrow	—	—	—	—	—	—	—	—	—	—	.3	—	—	—	—	—	—	—	—	—	—	—	.5	.1
Miscellaneous	3.3	20.4	6.9	54.3	1.0	28.3	9.8	13.5	4.9	28.7	30.4	36.6	.6	19.1	17.0	78.8	5.0	29.7	3.8	6.2	4.2	28.8	14.8	23.6

Natural conditions seem to have operated in the meantime with a levelling sweep, and the best plot at the best of centres even, is only a compromise between the contribution of sown species and that contributed by the miscellaneous unsown ones. Time will show whether this comparatively favourable compromise will be maintained, or whether the sward will continue to generate past a point below which it is patently uneconomic to maintain as grassland. The survival of so few of the sown species which we are accustomed to think of as in some degree permanent (timothy, meadow fescue, late flowering red clover and alsike) past that period, where in the main we trust to flying members such as Italian rye-grass and broad red clover, is a serious consideration for a grassland country such as ours.

Occurrence of Species omitted from the Mixture.

Dealing with these figures we have to bear in mind that the series for 1923 represent the sward in hay, while in the latter series, 1926, the pastures were grazed. This fact alone limits the conclusions we can draw from them.

In the second year's analysis it will be recalled that where they were not sown there was of Italian rye-grass or of cocksfoot no more than one would expect to have been established from seeds shed in carting over the plots. In the fourth year no Italian rye-grass plants occurred, and but a trace of cocksfoot at one centre only. No perennial rye-grass plants where unsown were found at Pinfold Farm, the percentage was small at Glasgraig and at the College Farm, being at both centres considerably less than where sown. It ranged from 8% to 12% at Plas-is-Llan, Fachell and Berthymaen, which proportions compare very favourably with its proportions elsewhere where sown in quantity. The significance of omitting timothy from the mixture cannot be estimated as on all the plots alike no more than a trace remains by the fourth year. With crested dogstail, on the other hand, the herbage in the fourth year reflects very faithfully the quantity of seed originally sown. On plot E, where it was omitted, representation throughout the series is very low; it is totally absent on the heavy soils of Fachell and Plas-is-Llan, with but a trace at the College Farm, Berthymaen and Pinfold. Even at Glasgraig on light land, when one considers that in the other plots it ranges between 26% and 38%, the 12% of it present is not of a high order of representation. This figure, however, does indicate that on light land it is an active colonist. On plot F, where half the normal seeding of crested dogstail was given, it is noteworthy that in all centres the distribution is

uniform with theoretical expectations, i.e., intermediate between that found on the full seeding plots and on the plots where it is not sown. The same is true of the representation of another bottom grass of the experiment—rough stalked meadow grass. At Berthymaen it is truly aggressive. There are but traces of it where not sown at Glasgraig and Fachell. Its representation is strong where unsown at the other centres yet short of what it is where sown. An initial half seeding is here also faithfully reflected up to the fourth year.

Effect of Omission of Species on the Development of Wild White Clover.

Wild white clover is highest throughout at the College Farm, and, with the exception of the anomalous centre Fachell, it is uniformly high (20%—40%) at the other centres. Representation in the full mixture plot (A) is low at Fachell and at Berthymaen. It is obvious that omissions of species as on plots B, C, D and E have favoured white clover to an increase throughout. At three of the centres this is highest where bottom grasses are omitted. The highest proportion of wild white clover found on any plot is on F where there was an excessive seeding of perennial rye-grass (15lb. per acre); at the remaining centres its representation on plot F is equal to its best on the other plots. It was not so in the centres examined in 1924-25. It was there exceptional to find the omission of other species benefitting the distribution of wild white clover.

The rate of increase seems to be little affected by the nature of the species omitted in each case, except that at Glasgraig and at Pinfold Farm omission of bottom grasses has enhanced it considerably more than other omissions have. In the light of this statement it is significant to recall that at the one centre—the College Farm—where omissions affected favourably the distribution of the bottom plants, crested dogstail, rough stalked meadow grass and yarrow, in the two series an increase of a desirable element came by way of a common factor.

The present analyses also bear out that there is marked affinity between perennial rye-grass and wild white clover, consistently borne out for the centres in this series.

Effect of Omission of Species on the Development of Miscellaneous Unsown Plants.

The figures for weed flora in the swards as examined for hay in the second harvest year scarcely serve as a basis for comparison with the winter analysis figures of the same ingredients of the sward and given collaterally here for obvious reasons. The former

figures represent the ingredients in the full flush of growth, the latter figures were arrived at in winter when the better quality herbage was grazed well down. The less attractive miscellaneous ingredients were mostly more lightly grazed. However, a mean representation of well over 30% weed flora in centres so variously placed over the area is a serious indictment either of the initial seeds mixture, or of management in the meantime, or of both. It is true that for the first three years of their course these leys had to conflict with an unbroken sequence of wet summers and winters alike. The extreme instance of deterioration through wet field conditions and concentrated stocking by sheep is shown at Fachell. At Plas-is-Llan, no great distance away, there is far less obvious deterioration, though the land there is obviously poorer. It is significant, however, that Plas-is-Llan carries no sheep, being exclusively a dairy farm.

It is gratifying to note further that the rise and fall of the percentage figures for the weed flora as we pass from plot to plot within each centre is, in the fourth year, essentially in the same order as it was at the second year of the life of the ley. One concludes, then, that the critical period where it might be possible to govern the entry of, and to attempt to check, such undesirable ingredients comes at some point in the life of the ley prior to the time it was first examined. A scrutiny of the individual ingredients constituting the miscellaneous group supports this also, in that the plant personnel is essentially the same at four years as it was at two and in the main was latently resident in the seed bed in the first instance.

At the anomalous centre Fachell miscellaneous plants were, on all plots, inordinately high. Even so it was highest on plot F, on which plot in the second year also it stood highest, having even by then trebled its bulk as compared with plot A. Couch grass had even at that time firmly established itself at Fachell. Berthymaen deserves mention because it alone stands apart from the other centres as having a very low representation of miscellaneous plants.

Having regard to the figures for wild white clover, the while we examine the figures for miscellaneous plants, some interesting conclusions are warranted.

Limiting one's observations as defined in the 1924-25 series simply to within the bounds of each centre, where the wild white clover figure is down the miscellaneous flora figure is high. Conversely a low figure for miscellaneous plants is directly reflected in a high figure for wild white clover at that point. This is very striking at Berthymaen and Fachell in plot A, where the

excess of weeds, 28% and 60% respectively, involves a shrinkage to 10% and 11% respectively in the wild white clover figures. With the passing of the fugitive Italian rye-grass element on plot B it is gratifying to find that the figure for miscellaneous plants for each centre is down as compared with that for plot A. Coupled with the fact that the wild white clover figure is up on each of these as compared with the same control plot A, we gather that with the passing of Italian rye-grass the vacant ground is filled, in part at least, with the desirable wild white clover element—an element aggressive when competing even with these weeds.

Effect of Omission of Bottom Grasses and other Species and Excess of Perennial Rye-Grass on Miscellaneous Flora.

Similarly with the omission of bottom plants, plot E, there is a drop in the figure for miscellaneous plants as compared with the full mixture, plot A. The explanation for this appears to be bound up with the appreciation of wild white clover on all these plots, clearly indicating that, in the race for occupation of vacant space arising out of the omission of ground species, wild white clover scored over the miscellaneous plants and weeds. This fact sets a value on wild white clover over and above any already assigned to it on the score of excellence for stock feed. If we examine the figures for perennial rye-grass and for weeds and unsown plants side by side on plot F, where an excess of perennial rye-grass was sown, we find a definite correlation. At the College Farm and at Fachell, where the rye-grass did not appreciate with the augmented seeding, the figures for miscellaneous plants show an advance on those for plot A with the more normal and standard seeding. At the other four centres, true of Glasgraig, but very marked at Plas-is-Llan, Berthymaen and Pinfold, where rye-grass appreciated markedly on plot F, the representation of miscellaneous plants is equally definitely much lower than it is on plot A.

One finds then that for centres suited to it a relatively high initial seeding of perennial rye-grass can with advantage be given, not only for the plant it gives, but also for the check to weed growth thus effected. The percentage representation of cocksfoot is throughout the plot so low that the figures do not warrant any definite conclusions to be drawn for the effect of its omission on the miscellaneous flora.

Nature of Miscellaneous Elements.

Percentage occurrences of the individual miscellaneous elements were made, but for economy of space they have to be

treated collectively in the tables here inserted. As their significance is more pronounced from plot to plot within each centre they are examined from that angle.

College Farm.

The weed flora is lowest (14%) on plot B. Elsewhere it ranges between 24% and 30% and contains no couch grass or Yorkshire fog. On plot B 7% of this is moss, which runs from 14%—20% on the other plots. The other ingredient of note is bent grass, highest on plots E and F (5%—7%) and lowest (1%) on B.

Glasgraig.

At this centre the miscellaneous flora was lowest in the absence of bottom grasses on plot E and highest on the full mixture plot A, where Yorkshire fog appears to the extent of 6%, with but traces of it elsewhere. The moss population ranges from 10% on plot C through 12% on plot F to 18%—22% on the others. Couch is absent, but on all the other plots agrostis ranges between 6% and 14%. This figure is not excessive for this area, for on the lighter land of Anglesey and S. Caernarvonshire this is the most difficult element to contend with in pasture establishment.

Fachell.

As previously mentioned the sward here is the least satisfactory of the whole series. The ground is waterlogged over wet periods, and degeneration is wholesale. Much bare ground shows in winter-time and couch grass has invaded all the plots. There were traces of this weed in 1923, but by 1925-26 it ranged from 5% to 24% over the plots. Similarly bent grass ranges from 8%, 10% and 13% on plots C, B and D respectively, through 17% on E to 42% on plots A and F. This evidence supports the view quoted in the last volume of this Journal (*loc. cit.*) that much of it at least came *via* adjacent plots not in the experiment. The moss flora is also high throughout.

Plas-is-Llan.

On the heavy ground here omission of perennial rye-grass has obviously intensified the weed flora, which is clearly highest on plot C. An augmented seeding of rye-grass has reduced it by half. This difference operates mostly through the agency of the moss and couch grass elements which are uniformly distributed on the other plots. Bent grass is high on plots A, B and C (21%, 14% and 14% respectively). It drops to 5% on the rest of the plots.

Berthymaen.

With the exception of the full mixture plot A the weed population at this centre is the lowest of all the centres in the whole series for all the years. The excess of weeds on plot A *correlates with the poor* representation of wild white clover on *this plot, while on the other plots the* paucity of weeds is largely explained by the excellence of the wild white clover take on them all. Traces of red fescue occurred on plots B and C, and with the exception of self heal, daisy and bent grass evenly distributed, no weeds occurred on the plots. The 28% weed flora of plot A consisted of moss and Yorkshire fog.

Pinfold Farm.

Here weeds have established themselves well on plots A, C and D. Elsewhere the representation is relatively low. The fluctuating elements responsible for this is the moss flora. Though Yorkshire fog and bent grass are common to all plots, with the exception of the latter on plot E, never do they figure beyond 5%. Couch is totally absent and other minor miscellaneous plants, though numerous in number of species, are evenly distributed over the plots. Here, also, it is significant that the non-occurrence of bent grass on plot E, where no bottom grasses were sown, should coincide with the highest representation of wild white clover for this centre.

General Conclusions with reference to Stability in Grassland in North Wales.

It is proposed here to examine the findings of this series of experiments started in 1919 and followed to date. As leading up to the problem, though not part of it, the reader is referred to another publication,[2] which established the general fact that of a comprehensive number of species it was customary to include in permanent seeds mixture for the area in the past very few form the valuable part of the permanent pasture. The species then included as of this class were perennial rye-grass, wild white clover, crested dogstail and rough stalked meadow grass.

The present series of experiments warrants the addition of only one other species—cocksfoot—to this list. A brief summary of the species sown in the 1920-26 series which still persisted in any quantity into the fourth and fifth year is included here (Tables III and IV), and a perusal of their contents together with

[2] "Formation of Permanent Pastures". R. Alun Roberts and Moses Griffith, Department of Agriculture, University College, Bangor. *Bulletin*, March, 1922.

the supplementary evidence of the other analyses submitted in this Journal warrant the following conclusions :—

TABLE III.

Sown 1920. Examined Winter 1924-25.
Percentages of Chief Plants in Fourth Year's Pasture.

CENTRE.	A *Full Mixture.*	B *No Italian Ryegrass.*	C *No Peren'l Ryegrass.*	D *No Cocksfoot.*	E *No Bottom Grasses.*	F *Peren'l Rye-grass Mixt.*
WILD WHITE CLOVER.						
College Farm ...	36·4	33·3	36·9	26·9	26·3	42·3
Ysgubor Hen ...	20·6	16·0	16·0	15·2	13·4	13·2
Llyslew ...	59·3	45·3	43·3	43·0	29·6	32·1
PERENNIAL RYEGRASS.						
College Farm ...	3·9	5·3	—	7·1	12·8	12·3
Ysgubor Hen ...	2·7	3·7	1·7	2·6	2·0	1·9
Llyslew ...	4·7	9·1	·5	3·8	4·5	4·3
COCKSFOOT.						
College Farm ...	22·6	8·4	7·4	—	8·0	2·7
Ysgubor Hen ...	6·6	5·4	7·7	·9	3·5	·7
Llyslew ...	·2	1·7	·4	—	·6	·1
TIMOTHY.						
College Farm ...	·3	·7	·4	13·3	4·0	1·0
Ysgubor Hen ...	1·2	1·3	1·2	·9	·2	—
Llyslew ...	—	—	—	·2	·2	—
CRESTED DOGSTAIL.						
College Farm ...	6·9	16·4	19·3	6·2	·2	11·0
Ysgubor Hen ...	14·0	3·8	5·2	3·0	3·1	6·3
Llyslew ...	1·6	2·9	2·4	4·0	1·9	7 9
ROUGH STALKED MEADOW GRASS.						
College Farm ...	14·9	21·3	21·4	15·9	16·5	22·6
Ysgubor Hen ...	16·8	34·3	39·8	34·7	41·9	43·9
Llyslew ...	13·5	13·8	17·8	20·4	32·5	19·1
MISCELLANEOUS.						
College Farm ...	10·5	12·4	12·0	28·1	28·8	6·6
Ysgubor Hen ...	37·5	37·1	26·9	42·7	35·9	31·0
Llyslew ...	19·7	25·4	34·8	26·6	29·7	35·0

By the time of the second analysis Italian ryegrass had almost completely disappeared at every centre. Traces remained at two of the centres of the earlier series. Its functions in the early years is, however, an important one in this area where young leys are mostly put up for hay, and where there is a heavy stock of sheep to be carried over the winter.

Meadow fescue and timothy were to be found only very occasionally and then but in very small quantities. It is noteworthy that these two ingredients figure on all the plots where included in the seed at Pinfold Farm, Bronington, the former up to 4% and the latter up to 8%. This fact has added interest when we realise that conditions at this centre departs from conditions

TABLE IV.

Sown 1921. Examined Winter 1925-26.

Percentages of Chief Plants in Fourth Year's Pasture.

	PLOTS.					
	A	B	C	D	E	F
CENTRE.	*Full Mixture.*	*No Italian Ryegrass.*	*No Peren'l Ryegrass.*	*No Cocksfoot.*	*No Bottom Grasses.*	*Peren'l Rye-grass Mixt.*
WILD WHITE CLOVER.						
College Farm ...	36·5	40·7	42·6	39·9	43·0	41·3
Glasgraig ...	21·8	23·8	26·8	26·0	44·2	45·3
Fachell ...	11·6	22·7	14·9	23·7	24·3	12·1
Plas-is-Llan ...	33·7	37·9	24·0	·33·8	32·7	40·6
Berthymaen ...	10·6	34·0	36·6	42·3	36·3	42·4
Pinfold ...	28·2	32·9	29·5	24·6	37·6	36·3
PERENNIAL RYEGRASS.						
College Farm ...	8·7	9·3	4·8	11·4	13·5	11·6
Glasgraig ...	·39	2·4	1·8	5·0	12·9	4·6
Fachell ...	12·8	6·6	10·2	3·4	17·3	9·1
Plas-is-Llan ...	10·9	9·9	8·3	8·8	14·1	20·3
Berthymaen ...	11·5	11·6	12·1	16·5	13·6	18·9
Pinfold ...	5·1	10·0	—	6·0	8·4	20·0
COCKSFOOT.						
College Farm ...	·1	·7	·1	—	·2	·5
Glasgraig ...	4·6	1·4	8·6	—	1·8	·1
Fachell ...	1·5	·7	6·7	·5	3·4	—
Plas-is-Llan ...	·6	·9	·8	—	1·7	·4
Berthymaen ...	1·9	3·7	6·0	—	6·9	1·9
Pinfold ...	6·5	1·8	3·4	—	7·4	8·5
TIMOTHY.						
College Farm ...	·1	·2	·1	·3	—	—
Glasgraig ...	T	·2	·4	·8	·5	·3
Fachell ...	—	—	—	—	—	—
Plas-is-Llan ...	—	—	—	—	—	—
Berthymaen ...	—	1·1	—	—	—	—
Pinfold ...	·8	·1	T	·1	·6	2·8
CRESTED DOGSTAIL.						
College Farm ...	15·6	13·3	10·2	9·1	2·2	10·0
Glasgraig ...	26·3	38·6	27·6	27·6	11·8	19·7
Fachell ...	1·6	1·5	2·6	1·0	—	—
Plas-is-Llan ...	2·8	2·8	1·4	4·4	—	·2
Berthymaen ...	11·5	4·5	5·9	6·9	1·2	5·7
Pinfold ...	1·2	1·2	1·1	1·5	·9	1·8
ROUGH STALKED MEADOW GRASS.						
College Farm ...	12·1	20·3	13·6	15·1	12·4	7·8
Glasgraig ...	4·2	1·2	5·7	2·6	·5	·3
Fachell ...	11·9	9·4	24·5	25·2	·7	—
Plas-is-Llan ...	13·1	15·8	18·8	17·5	14·9	14·8
Berthymaen ...	36·2	37·2	26·7	21·9	28·5	24·9
Pinfold ...	16·9	18·3	13·3	11·3	14·1	5·1
MISCELLANEOUS.						
College Farm ...	26·8	14·6	28·7	24·2	28·7	28·8
Glasgraig ...	39·2	32·1	28·5	37·3	28·3	29·7
Fachell ...	60·6	59·8	41·1	46·2	54·3	78·8
Plas-is-Llan ...	38·9	32·5	46·6	35·6	36·6	23·6
Berthymaen ...	28·3	7·1	12·7	12·4	13·5	6·2
Pinfold ...	31·7	22·1	43·9	50·7	20·4	19·1

on the western seaboard, where most of the other centres lie. It approaches the midlands and the findings here tend to modify the definite conclusions we are forced to from a consideration of results at all the other centres. Professor Percival[3] found in the Thames Valley that " all the species of plants sown are still found on the plots after nineteen years and weeds do not establish themselves on land sown with suitable mixtures of grasses and clovers and adequately manured and grazed ". With the exception of this centre, Pinfold Farm, the evidence of our centres negatives such a statement for this area. Pinfold stands intermediate between our findings for this western area generally and those found at Reading (*loc. cit.*), not only in persistence of the sown species, but also in its relative freedom from direct colonisation as between different plots. Here alone did perennial ryegrass fail to establish itself where not sown, though this species responded better to an augmented seeding on plot F than at any other centre. In short, it is at Pinfold Farm that we have had the nearest approach to theoretical expectations.

Red clover and alsike clover have to all purposes completely gone out of the pasture, while yarrow and chicory are represented by but a few plants here and there.

When we realise that after very few years the herbage on all these plots is drawn from less than half-a-dozen of the sown species blended with miscellaneous unsown plants in varying proportions, we are forced to conclude, once again, and definitely, that our seeds lists for permanent grass must be drawn strictly from this meagre handful of species with or without provision for a hay crop in the early years. To profitably extend our range of choice we must obtain indigenous species with an ascertained excellence in respect of persistency.[4]

To turn finally to the few persistent species we find that whereas in the former series the colonist members of perennial

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[3] " Notes on Some Permanent Grass Plots on the University Farm, Reading ". Professor John Percival, M.A., Sc.D. *Journal Ministry of Agriculture*, Vol. XXXIII, April, 1926.

[4] (1) Whereas commercial stocks of late flowering red clovers have proved very slightly if at all superior to broad red clover in the matter of persistence, it is by now definitely established that certified stocks of local strains of genuine late flowering red clovers with a normal life expectation of three or four years in a ley, are available, and agriculturists should concentrate on these. (2) We have also come to regard timothy as an essentially fugitive ingredient of a sown pasture, if it be grazed closely for a sequence of years. The study of fattening pastures in the North Wales area for the past two seasons shows a fair percentage of timothy on land that is grazed year in year out. This proves definitely that forms of this grass approaching the ideal for our needs already exist within our area. Similarly a fair frequency in the case of meadow fescue and fine-leaved fescue in pastures of high reputation warrants expectations of a better performance from native forms of these than from commercial stocks.

ryegrass that found their way to plot C had not been able to make much headway by the fourth year, in the second series it has done well at Fachell and Berthymaen. Likewise in the second series an extra application of the seed in plot F has resulted, with the exception of Fachell, in increased representation in the fourth year.

Cocksfoot must be regarded as a poor colonist, 7% is the top representation of it, but with meagre quantities on most of the plots. Whereas in the first series it was best represented on the full mixture plot A, its representation in the second series excels where perennial ryegrass and where crested dogstail have been omitted.

With the exception of the light land at Glasgraig crested dogstail has proved a very poor colonist. At the College farm in the first series the high representation which marked it on all other plots dropped to a trace on plot E where it was not sown. In both series it dominates cocksfoot and perennial ryegrass. It is uncommonly high throughout at Glasgraig and is undoubtedly of value on the lighter lands as a check on graminaceous weeds. The inversion of proportions between the figures for crested dogstail and rough stalked meadow grass as shown more especially in Table IV suggests clearly that they are rival bottom grasses and whereas rough stalked meadow grass has proved itself a most aggressive colonist and sward element by its spread to plots E and F where not sown, its relative absence from Glasgraig tends to show that on lighter land it has to give way to its rival, crested dogstail. Fourth year analysis of the second series further bears out a former statement that this meadow grass, flourishing though it be, is not likely to oust other good pasture plants. Tables III and IV show that wild white clover appears to control it to a great extent or to limit it to some degree. How these few sown ingredients will react amongst themselves as the pasture gets older we do not now know, nor do we know how far they will be able to compete with the miscellaneous unsown elements. Observations to date indicate that we have reached here what may be regarded as the preclimax stage. The ultimate stage may with judicious management and manuring be an indefinite prolongation of the ley with the balance of species mainly as they are. It is not easy to see how either management or manuring can with the climatic conditions and heavy winter stocking operating in the area improve these swards and maintain that improvement indefinitely so that an ultimate and stable balance of species be got that excels over this present penultimate stage.

Though Wales is a grassland country we must bear in mind that with the exception of a few areas to the summit of the higher hills and some of the valley bottoms, this grassland has to be artificially maintained and kept from retrogressing through scrub to its native woodland. Such a consideration suggests that the only true stability we can logically arrive at is the stability of ultimate degeneration. The results here found go far to support this. The best we can aspire to is to strike a balanced compromise between a suitable selection of sown species, bolstered up by judicious husbandry on the one hand, and the tendency to degeneration, natural and inviolate, on the other, and to strive to maintain this indefinitely. If to an extended range of initial species known to persist, and, where possible of a local or indigenous origin, we can bring a very sympathetic and mobile human element sworn not to waver in its purpose from year to year then and then only can a prolonged compromise with nature —a compromise approaching stability—be attained. Short of this, and until indigenous forms of those species now fugitive in our swards are regionally available, the only one and economic policy in the establishment and maintenance of sown grassland in this area is to depart forthwith from the old comprehensive seeds mixture—wasteful and uncertain in their take, and to concentrate on the few persistent elements that are available. This can also be profitably coupled with a saner and less fitful policy for the plough, whereby there is continuity in the arable fraction each year, and whereby the ley is broken up immediately it has ceased to be profitable and not when it is obviously degenerate.

Grateful acknowledgment is made to the Organisers of Agricultural Education in the North Wales counties where the experiments were laid down, and to the farmers on whose holdings the trials were accommodated. Thanks are also accorded to Mr. Frank Hughes, Laboratory Assistant in the Department of Agricultural Botany at Bangor, for invaluable help in the mechanical operations involved throughout this investigation. Finally, the author owes a debt of gratitude to Professor R. G. White, M.Sc., of Bangor, for his guidance and helpful criticism.

A SUMMARY OF EXPERIMENTS ON THE MANURING OF POTATOES IN ANGLESEY, CAERNARVONSHIRE, DENBIGHSHIRE AND FLINTSHIRE, 1892—1925.

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The four counties do not contain any large areas devoted to potato growing, such as are found in Lincolnshire, Cornwall, or even Cheshire, but nevertheless the crop is an important sideline in the area. Table I gives the acreage of potatoes in these counties at five-yearly intervals from 1895 to 1925.

TABLE I.

Year.	*Acreage under Potatoes in*				*Total.*
	Anglesey.	*Caernarvonshire.*	*Denbighshire.*	*Flintshire.*	
1895	2,811	4,619	3,438	2,610	13,478
1900	2,795	4,187	3,177	2,312	12,471
1905	2,533	3,943	3,019	2,033	11,528
1910	1,979	3,410	2,490	1,615	9,494
1915	1,945	3,497	2,405	1,625	9,472
1920	1,889	3,423	2,534	1,666	9,512
1925	1,587	2,711	2,196	1,499	7,993

It will be observed that the area under this crop has gradually decreased in each county, the total decrease amounting to approximately 50%. The crop is of great importance nationally because with the exception of sugar beet it enables more human food to be grown on an acre than any other crop. Agriculturally the crop is, in this district, an important converter of surplus and family labour into ready cash. The crop does not compete for labour to any serious extent with other farm crops; it may be planted before the other crops are sown or after the cereals have been drilled in, or it may be put down when weather conditions while not enabling a sufficiently fine tilth to be prepared for cereals might be good enough for opening and splitting ridges for potatoes. The crop competes against other root crops during the season of intertillage, but as it is an excellent cleaning crop this is not a disadvantage. The maincrop varieties are lifted after the corn harvest and may be got ready for selling in wet weather during the winter months. A small area of potatoes can be profitably grown on most farms,

even when it might seem unprofitable on paper by charging all labour against it. The small unsaleable tubers are useful for pig feeding either cooked or in the raw condition, about four pounds of cooked potatoes having approximately the same value as a pound of meal. Passing mention might be made of the fact that in times of potato glut, such as existed last autumn, quantities of ware are used as a stock food; the value of potatoes as a stock food is probably lower than is commonly supposed, and, for the month of November, 1926, for example, the value of a ton of potatoes as a stock food was approximately £2.

Place of Potato Crop in the Rotation.

The crop takes the place of the ordinary root crop in the rotation, coming between the two corn crops, the crop preceding it being generally oats (after grass). It is very seldom taken directly after grass as in many potato districts, the organic contents of North Wales soils and the plentiful supply of farmyard manure making this practice unnecessary.

Practice with regard to Manuring.

The crop is invariably given a dressing of ten to fifteen tons of farmyard manure, this manure being plentiful in a stock raising area. In Anglesey and Caernarvonshire the manure is often spread on the stubble in the autumn and ploughed in, but in Denbighshire and Flintshire it is almost invariably applied in the drills. The application of farmyard manure in the drills probably gives larger crops than when it is applied in the autumn, but in the latter case the amount of spring work is curtailed—an important consideration in districts of high rainfall, whereby farmers are enabled to take advantage of spells of fine weather for preparing seed beds and for sowing. In Anglesey and Caernarvonshire there is less "permanent" pasture than in the other two counties; this means a greater proportion of the land can be brought under the plough and consequently longer grass leys. This again makes the arable land less liable to couch grass, a condition favourable to the autumn application of farmyard manure. Artificial manures are not used to any large extent for potatoes, the heavy dressings such as are used in some potato districts being unremunerative.

1. Effect of farmyard manure on the yield.

The yield obtained by using a dressing of ten to fifteen tons of manure was compared with that obtained from untreated land at thirty-seven centres, with the following result:—

Average of thirty-seven centres (no artificials used).

Yield per acre with no farmyard manure, 5 tons 10 cwt.

Yield per acre with ten to fifteen tons of farmyard manure, 9 tons 11 cwt.

Increase of crop due to farmyard manure, 4 tons 1 cwt, or 74%.

The following table gives the number of instances where certain percentage increases were obtained.

TABLE II.

Percentage increase.	*No. of instances where increase given.*
0— 30%	4
31— 60	10
61—100	10
101—140	4
141—180	6
181—220	3
	37

Thus, there were only four instances where increases of less than 30% were given, two of these only being less than 10%.

2. Effect of an extra ten tons of farmyard manure.

The effect of adding an extra ten tons of manure to a moderate dressing (ten to twelve tons per acre) was tried at twenty-eight centres with the following result :—

Average of twenty-eight centres. (Weights per acre).

Weight of crop with ten tons manure, 9 tons 9 cwt.

Weight of crop with twenty tons manure, 10 tons 18 cwt.

Increase due to extra ten tons, 29 $\pm$ 14 cwt.

This difference is not significant, so that on the average it is doubtful whether the extra dressing increased the crop. An examination of individual results shows that at no centre was there an increase of 30% or more, and that only at eight of the twenty-eight centres was there an increase of more than 20%. Attention may be called to the fact that in a similar summary of mangel experiments it was concluded that the extra ten tons of farmyard manure could be more profitably employed on some other part of the farm.

3. Effect of a dressing of complete artificials compared with a dressing of farmyard manure.

Though the question of replacing farmyard manure is not one of importance under average North Wales conditions, there

are cases, e.g., in market gardens, where this manure might be difficult to procure. It should be noted that in these trials the results refer to one year's trial only at each farm, and would in all probability not be obtained if the potato crop was taken more than once in the rotation.

Average of thirty-five centres.

Weight of crop per acre with farmyard manure, 9 tons 18 cwt.

Weight of crop per acre with artificials, 9 tons 7 cwt.

Difference, 6 cwt.

The difference is obviously not significant, so that, taking the average of thirty-five centres, a dressing of complete artificials gave as good a crop of potatoes as a dressing of farmyard manure. It should be recollected that these trials were carried out in an area where the organic content of the soil is high owing to the rainfall and the system of farming practised there.

An examination of the results shows that at only three of the thirty-five centres was there a marked increase in favour of the farmyard manure. The complete dressing of artificials referred to consisted of

$$\left.\begin{array}{l}\text{202 lbs. Sulphate of Ammonia}\\ \text{164 lbs. Sulphate of Potash}\\ \text{524 lbs. Superphosphate (26\%)}\end{array}\right\}\ \text{per acre.}$$

4. Effect of a complete dressing of artificials given in addition to farmyard manure.

This trial was carried out at forty-two centres, the dressing of artificials approximating to that used above.

Average of forty-two centres.

Weight of crop per acre with farmyard manure alone, 10 tons 5 cwt. ± 8 cwt.

Weight of crop per acre with farmyard manure and artificials, 12 tons 7 cwt.

Extra crop obtained by addition of artificials, 42 ± 11 cwt., or an addition of 24.9%. Thus, in these trials the addition of artificial manure to farmyard manure resulted in an increased crop.

The following table shows the number of cases where certain percentage increases were obtained.

TABLE III.

Percentage increase.	No. of instances where increase was given.
0—10	13
11—20	7
21—30	13
31—40	3
41—50	2
51—60	0
61—70	2
Above 70	2

Thus there were thirteen instances where a return of less than 10% increase was given; that is, in nearly one trial out of three, it was doubtful whether an increase of crop resulted from the addition of the artificials to the manure. It should be noted, however, that in four cases an increase over 50% resulted.

5. Comparison of a heavy with a moderate dressing of artificials.

A dressing of

188 lbs. Sulphate of Ammonia
164 lbs. Sulphate of Potash } per acre
524 lbs. Superphosphate

was tested against one where half of the above quantities per acre was used. All plots received from ten to twelve tons farmyard manure per acre.

Average of twenty-eight trials.

Weight of crop per acre from full dressing, 12 tons 2 cwt. $\pm$ 9.3 cwts.

Weight of crop per acre from half dressing, 11 tons 2 cwt.

Difference in favour of full dressing, 20 $\pm$ 13 cwts.

This difference is not large enough to enable it to be said with any degree of certainty that it is due to the extra amount of artificials and not to chance.

An examination of individual cases shows that of the twenty-eight instances, there were

4 cases where increases of 20% or over were given by the extra half dressing.

10 cases where increases of between 10—20% were given by the extra half dressing.

14 cases where increases of less than 10% were given by the extra half dressing.

In a review of mangel manurial trials for the last thirty years it was found on the average that, as in the case of potatoes, a

moderate dressing of complete artificials proved as effective as one of twice the weight when used with farmyard manure.

6. Effect of quick acting Nitrogenous manures added to farmyard manure, phosphate and potash.

A dressing of 101 lbs. of sulphate of ammonia applied in the drills was tried at twenty-eight centres and nitrate of soda at four centres. Taking an average of the thirty-two centres the weights per acre were as follows :—

Weight of crop with complete dressing, 10 tons 7 cwt.

Weight of crop with complete dressing but nitrog. manure left out, 10 tons 0 cwt.

Difference in favour of dressing containing sulphate of ammonia, 7 cwt.

This difference is too small to be significant, and thus, on an average of thirty-two cases, the dressing of quick-acting nitrogenous manure did not justify itself.

An examination of individual results shows that an increase of 20% or over as a result of application of nitrogen was obtained in one case, of 10—20% in ten cases, and of less than 10% in seventeen cases.

7. Effect of applications of potash.

The addition of various forms of potash manures was tested in forty-six instances, the potash being given in addition to farmyard manure, superphosphate and sulphate of ammonia. The dressings of potash per acre consisted of

2 cwts. sulphate of potash in six cases.

82 lbs. sulphate of potash in twenty-six cases.

1 cwt. sulphate of potash in six cases.

4 cwt. kainit in four cases.

Flue dust equivalent to 1 cwt. sulphate of potash in four cases.

Taking the average of the forty-six comparisons the weights per acre are

Yield with potash application, 11 tons 10 cwt.

Yield without potash application, 10 tons 19 cwts.

Increase due to potash, 11 cwt.

The average increase of 11 cwt. is too small to be significant, showing that, on the average, potash manures gave no appreciable return.

An examination of individual results, however, shows that while potash applications proved ineffective in the majority of instances there were some cases where a definite response was

given. Thus there were six cases where an increase of 20% or over was given by the potash manure; at one centre the four potash plots showed increases of 19, 25, 29 and 33%. It may be concluded that in the majority of instances potash does not appear to be needed, but that there are a few cases where a good response is given.

General Conclusions.

1. The application of ten or fifteen tons of farmyard manure was followed by large increases of crop, the mean increase amounting to over four tons, or 74%.

2. No significant increase of crop was given by an extra ten tons of manure.

3. Under average North Wales conditions, *i.e.*, taking one root crop in a rotation where the land is down to grass for several years, the replacement of farmyard manure by a dressing of artificials was not followed by diminution in the crop.

4. In the majority of the trials a dressing of complete artificials produced an appreciable increase of crop when added to farmyard manure.

5. A moderate dressing of complete artificials proved as effective as one of double the weight when added to farmyard manure.

6. Quick acting nitrogenous manures produced little or no effect when added to farmyard manure, phosphate and potash.

7. While potash manures proved ineffective in the majority of cases the trials showed that some soils were in need of this manurial ingredient even when farmyard manure was used.

CLOVER PROBLEMS.

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I. INTER-VARIETAL COMPETITION.

In view of the fact that both early and late flowering red clovers are frequently included together in mixtures for temporary leys, it is important to discover whether these clovers are mutually antagonistic when grown in competition with each other.

Two experiments, namely, A 91, Parts I and II, were laid down in 1924 to investigate this problem. As it is impossible

to separate the two clovers accurately when they are grown together under broadcast conditions, these experiments were sown in drills, English broad red, representing the early flowering, and Montgomery, the late flowering clovers, being used throughout. The seeds were sown in April 1924, at a uniform rate by means of a small drill. The rows had been previously marked out in order to ensure that they were sown at regular distances apart.

The plots were mown in October 1924, but no yield data were secured until the first harvest year (1925), when each drill was cut separately as hay on the 15th June and as aftermath on the 19th August, and the produce carefully air-dried before being weighed. The drills were 20 feet long, but before the plots were cut one foot at each end was discarded so as to eliminate any possible error arising from marginal effects.

Experiment A 91. I.

In this experiment the broad red and Montgomery were sown in alternating plots of three drills each (see Fig. 1) with 12 inches between the drills; each variety was replicated four times.

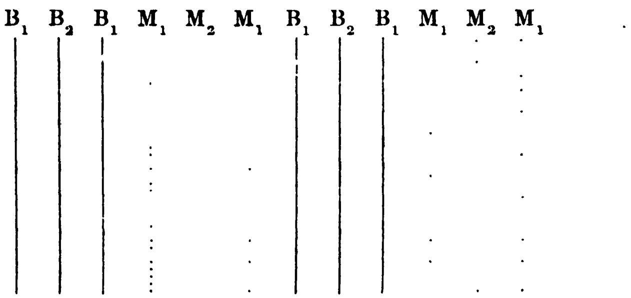

Fig. 1.—Black lines represent broad red and the dotted lines the Montgomery drills.

The object of the experiment was simply to ascertain if there was any border effect when the two varieties were grown alongside each other, by comparing the yields of the centre and adjacent drills. The actual and relative yields calculated according to Student's method of interpreting the results of paired experiments are given in Table I.

As seen in Table I, in the case of Montgomery the centre drills which were not subjected to competition with broad red gave decidedly heavier yields of both hay and aftermath than the adjacent drills which were exposed on one side to competition with the early variety. The very high odds prove that these differences are very significant. It therefore follows that broad

red had a depressing effect on the growth of Montgomery even when the drills were as much as 12 inches apart. On the other hand, these results suggest that Montgomery had but little and possibly no effect on broad red drills when sown at this distance apart, as the odds show that there is no significant difference between the yields of the centre and adjacent drills of the early variety.

TABLE I.

Giving the actual and relative yields of hay and aftermath of the centre and adjacent drills of English broad red and Montgomery red clover. Actual yields are given as oz. of air-dried fodder per 18 feet drill.

Yields.	*Crop.*	*Montgomery.*			*Broad red clover.*		
		Centre drill.	*Adjacent drill.*	*Odds.**	*Centre drill.*	*Adjacent drill.*	*Odds.**
Actual.	Hay	41.1	35.8	144:1	31.1	32.3	5:1
	Aftermath	10.2	9.1	550:1	10.8	10.6	1:1
	Total	51.3	44.9	147:1	41.9	42.9	4:1
Relative.	Hay	100	87.3		100	104.0	
	Aftermath	100	88.6		100	97.8	
	Total	100	87.5		100	102.5	

* These figures represent the odds that the differences between two results are significant.

Experiment A 91. II.

In this experiment the drills were sown at 6 inches apart and were arranged as shown in Fig. 2.

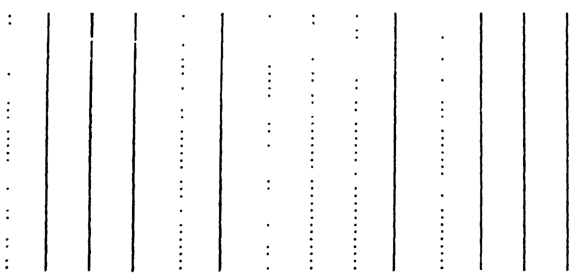

Fig. 2.—Black lines represent broad red and the dotted lines the Montgomery drills.

The plots, which consisted of 10 drills each, were replicated four times. To facilitate the discussion of the results the drills may be conveniently divided into 6 classes according to the

degree of inter-varietal competition to which they were subjected, namely, Montgomery drills : (1) surrounded by Montgomery, (2) adjacent to broad red, and (3) surrounded by broad red; and again, broad red drills : (4) surrounded by broad red, (5) adjacent to Montgomery, and (6) surrounded by Montgomery.

The yield results are summarized in Table II.

TABLE II.

Showing the effect of competition between Montgomery and English broad red clovers on the yields of hay and aftermath during the first harvest year. The actual yields are given as oz. of air-dried fodder per 18 feet drill.

		Montgomery drills.					*Broad red drills.*				
Yields.	*Crop.*	*Centre surrounded by Mont.*	*Adjacent to broad red.*	*Odds.*	*Surrounded by broad red*	*Odds.*	*Centre surrounded by broad red.*	*Adjacent to Mont.*	*Odds.*	*Surrounded by Mont.*	*Odds.*
Actual.	Hay	16.7	15.8	4:1	12.8	35:1	15.7	17.0	19:1	18.8	153:1
	Aftermath	5.7	4.7	11:1	3.3	155:1	7.5	8.3	18:1	9.8	50:1
	Total	22.4	20.5	5:1	16.1	58:1	23.2	25.3	24:1	28.6	75:1
Relative.	Hay	100	94.5		76.8		100	108.2		119.3	
	Aftermath	100	83.7		58.1		100	110.7		129.9	
	Total	100	91.7		72.1		100	109.0		123.1	

Effect of broad red on the growth of Montgomery clover.

The relatively low yields of the Montgomery drills adjacent to and surrounded by those of broad red, as compared with the centre drills of Montgomery, show that the early flowering clover had a very decided depressing effect on the growth of the late clover; for instance, the drills surrounded by broad red yielded 27.9 per cent. less dry fodder than the centre drills which were not subjected to inter-varietal competition. The influence of broad red in retarding the growth of Montgomery was probably due in the main to its shading effect. The broad red clover started growth four to five weeks earlier in the spring than Montgomery, and in spite of the spreading and more aggressive habit of the latter it was able to maintain the advantage in height gained in the spring by virtue of its more rapid and erect growth during May. The very rapid growth which broad red makes after it has been cut for hay also explains why its depressing effect on Montgomery was even more noticeable in the aftermath than in the hay crop.

Effect of Montgomery on the growth of broad red clover.

Broad red clover grown in competition with Montgomery actually gave increased yields of hay and aftermath; the aggregate increase of the drills completely surrounded by Montgomery was 23.1 per cent. and of the adjacent drills 9 per cent., as compared with the yields of the drills which were not in competition with the late variety.

It is interesting to note that this increased yield of broad red practically counterbalanced the decreased yield of Montgomery, with the result that the aggregate yields of the early and late varieties when grown in close competition were nearly equivalent to the combined yields of the two varieties when grown separately.

Summary.

1. When the early and late varieties of red clover, such as English broad red and Montgomery, are sown together, it has been shown that there is an intense competition between the two varieties, resulting in reduced yields in the late variety and increased yields in the early variety.

2. The retarding influence of the early variety on the growth of the late variety is probably mainly due to the shading effect of the former.

3. The decreased yields of the late clover resulting from the inter-varietal competition were practically compensated for by the increased yield given by the early variety.

4. It appears, therefore, that in spite of the intense competition which occurs when two red clover varieties differing widely in their habits and times of growth are sown together, there is no material reduction in the aggregate yields of the two clovers during the first harvest year. But the fact that broad red, like all other early flowering red clovers, behaves essentially as a biennial and that only a small proportion of the plants are able to survive into the second year should always be considered when drawing up mixtures for leys intended to be down for more than one year.

II. THE EFFECT OF THE TIME OF CUTTING MONTGOMERY RED CLOVER FOR HAY ON THE YIELDS OF HAY AND AFTERMATH.

The various varieties of red clover differ so widely in the time taken to reach full growth that it is often difficult to decide as to the best time of cutting hay crops consisting largely of red clover. When the crops contain English broad red or any of the

other early varieties they are usually mown about the second or third week in June when the red clover is practically in full bloom, but the problem is by no means so simple in the case of crops consisting largely of the very late varieties, such as Montgomery and Cornish Marl, as these clovers are not fully developed until the second or third week in July, while most of the grass constituents are usually ready for cutting about the end of June.

In 1925 two experiments, namely, A 90, Parts I and III, were carried out to determine the effect of cutting Montgomery red clover for hay at different times, on the hay and aftermath yields.

Experiment A 90. I.

In this experiment Montgomery was sown alone in April 1924 in drills 20 feet long and one foot apart at the rate of about 15 lb. per acre. The plots, which consisted of five drills each, were arranged in pairs, one of which was a control and the other a test plot. The control plots were cut for hay on the 17th July, while the test plots were cut on the 15th June, 2nd and 31st July, five plots being allocated to each date. The aftermath on all the plots was cut on the 1st September. As the experiment had been cut in October of the previous year, the aggregate weights of the hay and aftermath represented in each case the total growth made during the period from October 1924 to 1st September 1925.

TABLE I.

Giving the average hay and aftermath yields of Montgomery red clover mown for hay at different times.

Date of cutting the hay.	*Oz. of air-dried fodder per plot.*			
	Hay.	*Aftermath.*	*Total.*	*Odds.*
July 17th	117.6	37.3	154.9	23 : 1
June 15th	89.0	44.9	133.9	
July 17th	121.3	36.5	157.8	3 : 1
July 2nd	110.4	44.1	154.5	
July 17th	118.6	37.1	155.7	195 : 1
July 31st	97.9	27.7	125.6	

In order to eliminate any marginal or border effects which may have ensued as the result of cutting adjacent plots at different times, the growth from the two side drills and from one foot at each end of the remaining three centre drills of each plot was discarded.

The results calculated according to Student's method of comparing the results of paired experiments are summarized in Table I.

The stages of growth of the clover varied considerably at the different times of cutting. On 15th June (first cut) it was showing no signs of flowering and most of the plants were in the early bud stage; on 2nd July (second cut) there was an occasional head in bloom, but most of the plants were in the late bud stage; on 17th July (third cut) the crop was flowering fairly freely; while on 31st July it had passed the full bloom stage and many of the heads had started to turn brown.

The results given in Table I show that there were great differences in both the hay and aftermath yields of the plots cut at different stages of growth. These differences are brought out more clearly by the relative figures given below, which are based on the results shown in Table I.

	15th June.	*2nd July.*	*17th July.*	*31st July.*
Hay	76	91	100	83
Aftermath	120	121	100	73
Total	87	98	100	81

If the yields obtained from the plots cut on the 17th July are compared with those obtained from the plots cut on the 15th June and 2nd July, it will be seen that early cutting had the effect of reducing the weights of hay but of increasing the amount of aftermath produced. The plots cut on the 2nd and 17th July produced on the aggregate very similar yields, the reduced hay yields of the 2nd July plots being nearly counterbalanced by a corresponding increase in the aftermath; but the fact that the plots cut on the 15th June produced only about the same amount of aftermath as the plots cut two weeks later suggests that the very early cutting had a depressing effect on the aftermath growth. The comparatively low hay yields obtained from the plots cut on the 31st July is probably explained by the fact that a considerable proportion of the bottom leaves were lost owing to shedding before and after the plots were cut.

Experiment A 90. III.

This differed from the previous experiment in that it was carried out under normal field conditions on a "seeds mixture" consisting of perennial rye-grass, cocksfoot and meadow fescue, as

well as Montgomery red clover. The seeds were sown in June 1924. The field was grazed intermittently by sheep until the following April, when it was kept for hay. Before being put up for hay a part of the field was marked out lightly into 1/100th acre plots separated by paths three feet wide which were cut out before the plots were mown. The plots were arranged in eight pairs, one plot of each pair being used as a control and the other as a test plot. Four of the test plots were cut for hay on the 6th July,[1] when the clover was just starting to flower, the control plots on 20th July, when fifty to seventy-five per cent. of the plants were in bloom, and the other four test plots on the 6th August, when the crop was in the early seeding stage. The aftermath of both control and test plots was cut on the 17th September.

Each plot was weighed immediately after cutting; a three lb. sample was taken from each plot in order to determine its air-dried weight, and a two lb. sample to determine the percentage amount of clover present. The results are summarized in Table II.

The green weights are not included because it was found that the percentage air-dried weights of the green produce vary considerably according to the time at which the plots were cut, and as seen from the data given below the green hay and aftermath of the late plots contained a much higher proportion of dry matter than those of the plots cut four or even two weeks earlier.

Percentage air-dried fodder in the green hay and aftermath.

	6th July.	*20th July.*	*6th August.*
Hay ...	30.2 ...	33.8 ...	34.3
Aftermath ...	21.1 ...	20.8 ...	26.2

If the yields obtained from the early (6th July) and the control plots (20th July) are compared, it will be seen that the early plots yielded a poorer hay crop but a better aftermath than the control plots cut two weeks later. In other words, a corresponding increase in the aftermath completely compensated for the reduced yield of hay obtained as a result of the early cutting.

Again, if the hay yields of the control (20th July) and the late plots (6th August) are compared, it will be seen that the late plots produced a heavier crop of clover but a lighter crop of grasses and clovers combined. This apparent anomaly is probably explained by the fact that while a large proportion of the

[1] This experiment was also used by Mr. J. R. W. Jenkins, Adviser in Agricultural Entomology, in connection with the study of the insect pests on red clover. The times of cutting were therefore arranged to meet the requirements of these investigations.

TABLE II.

Showing the average yields of hay and aftermath obtained from plots consisting largely of Montgomery red clover cut at different times. The yields are given as lb. of air-dried fodder per 1/100 acre plot.

Date of cutting for hay.	*Grasses + Clover.*				*Clover alone.*			
	Hay.	*Aftermath.*	*Total.*	*Odds.*	*Hay.*	*Aftermath.*	*Total.*	*Odds.*
20th July.	59·0	15·7	74·7	5 : 1	34·2	10·1	44·3	1 : 1
6th July.	51·0	22·1	73·1		27·6	16·9	44·6	
20th July.	59·8	14·8	74·6	75 : 1	36·6	8·7	45·3	1 : 1
6th August.	61·8	6·3	68·1		42·9	2·1	45·0	

grasses, especially of the perennial rye-grass, had become very ripe and had started shedding seeds when the late plots were cut, Montgomery, by virtue of its late growth, was able to take advantage of the rain which fell towards the end of July after a long drought. The percentage weights of air-dried clover in the hay of the three cuts are interesting in this connection. These are :—

6th July.		*20th July.*		*6th August.*
54.8	...	59.4	...	69.2

The amount of aftermath produced was influenced to a marked degree by the time of cutting the hay. This fact is brought out very strikingly by the percentage figures below. The relative weights of aftermath secured from plots cut for hay at different dates were :

	6th July.		*20th July.*		*6th August.*
Grasses + Clovers ...	140	...	100	...	43
Clover alone ...	168	...	100	...	28

The early plots yielded about five times as much clover as the late plots. ...

Samples of the clover from the hay and aftermath of each of the three cuts were analysed by Mr. T. W. Fagan, the Advisory Chemist to the Agricultural Department. The results of the analyses briefly summarized by Mr. Fagan are given below.

The agreement in chemical composition of the clover from the plots cut on the same date in Experiment A 90. III. was so close, that the average figures only are given. Thus in Table III the figures giving the analysis for that cut on the 6th of July (early) represent the average of four plots, that cut on the 20th (medium) the average of eight, and that on the 6th of August the average of four plots.

TABLE III.

HAY. (Dry Matter).

	Ether Extract.	*Crude Protein.*	*True Protein.*	*Fibre.*	*Ash.*	*Soluble Carbo-hydrate.*	*Silica.*	*Phosphoric acid.* (P_2O_5)	*Lime* (CaO)	*Chlorine* (Cl)	*Nitrogen* (N)
Hay Cut—Early: 6th July.	2·54	15·94	13·41	31·92	7·77	41·83	0·30	0·45	3·21	0·280	2·55
,, ,, —Medium: 20th July.	2·17	13·14	11·20	33·20	7·32	43·87	0·20	0·39	2·79	0·262	2·19
,, ,, —Late: 6th August.	2·09	13·00	11·44	35·34	6·76	42·81	0·22	0·39	2·58	0·252	2·08

On comparing these figures, the superiority in chemical composition of the early cut clover is seen in the higher percentage of crude and true protein, ash, phosphoric acid and lime, while its fibre content is lower. As the date of cutting is delayed, there is a considerable reduction in all these constituents with the exception of fibre, in which there is a corresponding increase.

The composition of the clover cut at the two later dates does not differ to the extent that might be expected. Two factors might account for this, the growth of young shoots at the base of the clover cut at the late date which would enhance its chemical composition, or there might have been a certain loss of leaf in the making at both dates.

The aftermath of all the plots was cut on the 17th August, those that had been cut for hay on the same date being pooled. Three separate lots were thus obtained for analysis, the result of which is given in Table IV.

> The aftermath of the "early" cut hay represents eight weeks' growth, the "medium" cut six weeks' and the "late" cut hay four weeks' growth. The aftermath of the medium cut hay compared with that of the hay cut early, as would be expected being younger growth, is richer in crude and true protein, ash, phosphoric acid and lime and contained less fibre. The aftermath of the late cut hay, however, compared with the medium does not show the differences one would expect. Of the three aftermaths that of the "medium" cut hay appears from these figures to be the richest.

The above analyses suggest that the clover from the early plots had a much higher feeding value than that from the plots cut two and four weeks later. The hay from the plots cut on the 6th July was decidedly more leafy than that from the plots cut two weeks later, while the hay from the late plots was distinctly stemmy and hard.

Unlike the early flowering varieties which seldom become laid, the late varieties almost invariably become laid some time during the flowering period. The tendency to lodge is particularly marked in Montgomery and in Cornish Marl which, when the mowing is delayed, generally become so badly laid that considerable difficulty is often experienced in cutting the crop even in one direction. If only for this reason, hay crops containing these two clovers should be mown fairly early before they become laid.

TABLE IV.

AFTERMATH. (Dry Matter).

Aftermath from	*Ether Extract.*	*Crude Protein.*	*True Protein.*	*Fibre.*	*Ash.*	*Soluble Carbo-hydrate.*	*Silica.*	*Phosphoric acid.* (P_2O_5)	*Lime* (CaO)	*Chlorine* (Cl)	*Nitrogen* (N)
Early cut hay ...	2·48	23·81	20·50	24·55	8·60	40·56	0·35	0·640	3·14	0·686	3·81
Medium cut hay ...	3·45	26·06	23·13	21·88	10·00	38·61	0·37	0·670	3·46	0·745	4·17
Late cut hay ...	4·00	24·56	23·31	21·50	10·67	39·27	0·45	0·630	3·22	0·767	3·93

Summary.

The results of the two experiments on the effect of the time of cutting Montgomery clover hay on the yield of hay and aftermath are briefly epitomized below :—

1. It has been shown that the time of cutting the hay has a very considerable influence on the yields of hay on the one hand and the aftermath on the other.

2. Early cutting resulted in a reduced yield of hay but in an increased yield of aftermath.

3. The results seem to indicate that provided the crops are cut not earlier than the end of the third week or the fourth week in June and not later than the end of July, the reduced yield of hay which results from the early cutting is compensated for by a corresponding increase in the aftermath and *vice versa,* so that the aggregate yields of the hay and aftermath of crops mown during this period will be practically the same.

4. Very early cutting not only had the effect of reducing hay yields very materially, but apparently it had also a slightly depressing effect on the aftermath growth. This was noticeable in the case of the plots cut as early as the 15th June, when the clover was still in the very early bud stage.

5. In one experiment there was considerable reduction in the aggregate yields of clover when the plots were not cut until the end of July, and in the other experiment a decided reduction in the aggregate yields of grasses and clover when the cutting was delayed as late as the 6th August.

6. The results of the chemical analyses show that the hay from the early plots was of much higher nutritive value than that from plots cut two or four weeks later.

7. Late flowering varieties of red clover, such as Montgomery, are apt to become laid during the early stages of flowering. When badly laid the crops are very difficult to mow.

8. When all the various factors involved, such as the amount of hay and aftermath produced, the feeding value of the produce, and the tendency of the clover to become laid are taken into consideration, one is forced to the conclusion that the best time of cutting crops consisting largely of Montgomery red clover for hay is during the last week in June or the first week in July.

STUDIES ON BOG-HAY.

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In many districts in Wales the main type of winter fodder available is the hay harvested from what is known locally as " rhosdir " and " bog." This herbage, popularly known as bog-hay, in different localities goes under the names " gwair rhos " or " rhosyn," " gwair cwta," " gwrychyn mochyn," " gwair gwyllt," and " gwair cors."

Although a fairly clear distinction may be drawn between rhosdir and bog, the type of land associated with the former varies considerably from district to district, with the result that some confusion exists as to its proper interpretation. In some localities the transition from rhosdir to bog is known as "gwaun," the latter being wetter than rhosdir and drier than bog. On the other hand, " gwaun " in other districts indicates a portion of an arable field too wet to be ploughed but from which hay is harvested, the hay being known as " gwair gwaun."

Rhosdir is usually associated with soil of a peaty nature, having a substratum of boulder-clay; the depth of peat varying from inches to feet. The peat in cases has been pared off for fuel purposes with the result that the clay subsoil is very near the surface, consequently such areas are liable to suffer from drought. The term " rhosdir " is also applied to areas with little, if any, peat, that remain wet and marshy for a considerable period of the year owing to their position and high rainfall.

Bog, on the other hand, is associated with a great depth of peat, the actual depth and nature of the subsoil being often unknown. This is wetter than rhosdir and contains stagnant water. It occurs at high and low altitudes in the form of wet pockets or covering fairly large areas.

Typical examples of " rhosdir " and " bog " are to be found in the College area, *e.g.*, Cardiganshire, Breconshire and Merionethshire, while there are also large tracts in Snowdonia.

The herbage of " rhosdir," which is its most characteristic feature, has a brownish stunted appearance, owing to the nature of the soil and climatic conditions under which it grows. The vegetation includes the following species :—Molinia (purple heath grass), Nardus (mat grass), Carex (sedges), Triodia (heath grass), Agrostis (bent), Tufted Scirpus (Scirpus caespitosus) and Juncus (rushes), with small amounts of Anthoxanthum (sweet vernal), Holcus lanatus (Yorkshire fog), Bog Ashphodel, Tor-

mentil and Equisetum (horsetail). The extent to which individual varieties occur seems to depend on the degree of wetness of the soil. On the drier areas we find sheeps fescue, bent, wavy hair grass, sedges and sweet vernal with small amounts of other grasses, but as the moisture content increases, Molinia becomes dominant while Nardus occurs on still wetter parts. On areas where Molinia predominates and from which a few feet of peat have been removed, Nardus often makes its appearance owing to the new surface being wetter. The bog-proper is often associated with a considerable growth of cotton sedges and Bog Ashphodel with an underlying stratum of sphagnum moss.

The type of vegetation which the farmer generally associates with rhosdir and bog is illustrated by the botanical composition of the hays shown in the appendix. A cursory examination of these shows the wide variation in the type of herbage forming so-called bog-hay, some being composed of one or two varieties, while others are made up of several types of vegetation. The following associations may, however, be taken as typical of the vegetation of the rhosdir proper (abstracted from appendix) :—

Sample (1) (A)* *from Glandovey, Cardiganshire.*

Molinia	99%
Bog Ashphodel	1%

Sample (3) (A) *from Bala, Merionethshire.*

Nardus	80%
Bent	10%
Bilberry	5%
Sphagnum moss	5%

Sample (12) (B) *Nant-y-frwydr, Near Ffestiniog.*

Nardus	50%
Yorkshire fog	10%
Sedges	10%
Heath grass	10%
Miscellaneous	20%

Sample (2) (A) *from Trawsfynydd, Merionethshire.*

Molinia	80–90%
Bent	5%
Sheep's fescue ...	5–10%

Sample (9) (A) *from Dolbenmaen.*

Molinia	Trace.
Sedges and Cotton sedges	5–10%
Yorkshire fog ...	Trace.
Tufted scirpus ...	90%
Ling, Tormentil; Moss (Polytrichum, Sphagnum)	Trace.

* A and B refer to Appendix A and Appendix B.

From the above it is seen that the number of species present in the different samples may be small, and that the relative amounts of different species, like Molinia and tufted scirpus, varies within wide limits. Thus Nardus may be present to the extent of 80% or entirely absent.

The following samples may be taken as illustrating the type of vegetation often found growing on " bogs " :—

(1) *Sample from Lleyn* (A).

Sedges and Cotton sedges	90%
Molinia	5%
Juncus, Equisetum	Trace.

(2) *Sample from Lleyn* (B).

Cotton sedges	60%
Bog Ashphodel	10%
Molinia	20%
Miscellaneous	10%

Sample (3) from Lleyn (B).

Molinia	50%
Sedges	40%
Bog Ashphodel	10%

On comparing the botanical composition of the above types with the following, also regarded by farmers as bog-hay, the variation in botanical composition is seen to be very pronounced :

Llanuwchllyn.

Bent	10%
Rushes	20%
Devil's bit	5%
Yorkshire fog	5%
Sweet vernal	5%
Knapweed	5%
Crested dogstail	5%

Sample from Bala.

Wavy hair-grass	10%
Bent	20%
Sheep's fescue	60%
Miscellaneous	10%

Sample from Parc, Bala.

Wavy hair-grass	40%
Bent	10%
Sedges	5%
Sweet vernal	5%
Nardus	30%
Rush (Juncus)	5%
Meadow vetchling, Tormentil and Yorkshire fog	Trace.

Sample from Penrhyndeudraeth.

Rushes	85%
Bent	10%
Rough S.M. grass ...	5%

Thus, while bog-hay proper is composed mainly of a few species of the poorer types of grasses, the herbage that the farmer associates with rhosdir may contain a number of species, some of which, like sheep's fescue, are generally associated with a better type of soil.

The time of cutting and general method of harvesting bog-hay.

The time at which bog-hay is cut varies considerably in different districts.[1] In some localities, such as Trawsfynydd, the custom is to cut about the beginning of July, before they start on the hay proper, while in other districts, such as Lleyn (Cors Geirch), bog-hay is normally cut from about the end of July to the middle of August, but in wet and late seasons the time of cutting may be as late as the end of August or even the beginning of September, the hay being cut after harvesting the hay from arable land.[2] Where the only type of hay cut is bog-hay the hay harvest is often continued until fairly late. In the past, the general method of harvesting bog-hay was to cut as much as possible with a scythe in the morning, while dew is on the grass, as the wiry nature of grasses like Molinia makes it difficult to cut when dry, and owing to the skill required for cutting this type of hay it was recognised in these districts as the real test of the ability of a farm labourer. Even to-day a good deal of

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[1] The influence of this factor on chemical composition is given on page 126.

[2] In some districts what is known as Meadow Hay is really Bog-hay (e.g. Cors Geirch).

this type of hay is cut with a scythe, but where possible mowing machines are now used.

The scantiness of the herbage makes the cutting of bog-hay a costly item, while it is getting more difficult, with the introduction of farm machinery, to get men who are experts with a scythe to undertake this work. There is an old saying in many parts of Wales that "what a man can cut during the day he can carry home at night." Owing to the spongy nature of the land and the presence of boulders and outcrops, it is rare that mowing machines can be used on these areas, while the nature of the herbage makes it difficult to cut close with a machine. For these reasons the cutting of bog-hay is not very profitable at the present time, and enquiry has shown that on farms which are not wholly dependent on bog-hay for their winter fodder it is considered more economical to increase the hay yield on the arable land by suitable seed selection and manuring. On many upland farms, however, the areas that can be termed "arable" are very scarce and are generally utilised for oat growing. The produce, on the other hand, requires very little harvesting compared with other types of hay, a factor of considerable importance in these regions of high rainfall, while if put into "cocks," as is the custom when the weather is unfavourable, it keeps for a long time without deteriorating and becoming mouldy, as is the case with hay from arable land. Further, even when the cocks are soaked through, after a tumble and a rough spread this type of hay dries very quickly, so that often after a rainy morning the hay is "carted" in the afternoon. Thus the ease with which it is harvested, especially in bad weather, counteracts to some extent the laborious cutting.

Bog-hay is normally carted when "heavy" or "green," so that the hay gets heated and well consolidated in the stack, for it is believed that such a practice adds to the "palatability" of the hay owing to its aroma. It is of importance to note, however, that if carted in too heavy a condition, though, owing to the stack being well consolidated, there is little risk of firing, the hay when fed has a reddish appearance (gwair wedi cochi) and is inferior both in palatability and nutritive value. If carted at the right stage it is green in the stack in winter and is greatly relished by the stock.

In certain localities, where the shepherd lives in the "lluest" in the hills, bog-hay is the only winter fodder used, while on many upland farms it forms the main winter fodder. In these districts bog-hay is of considerable importance. On lowland farms the amount of bog-herbage cut for hay depends to a large

extent on the season and the supply of other forage crops available. The custom is to cut as much bog-hay as possible when other crops are short, the hay from the best areas being used for feeding, the poorer and coarser type for bedding. On the other hand, when straw and fodder is plentiful, only the better portions of bog-hay areas are cut. If the uncut areas are not grazed this practice gives the coarser types a better opportunity for colonising, with the result that if cut for hay the following season the produce will be poorer and will consist of a certain amount of old vegetation. To counteract this it is the custom in some districts, more especially the Molinia areas around Plynlymon, to cut different portions every alternate year, and in the intervening year to burn the old bottom growth either in late autumn or March so that the hay or grazing consists entirely of new growth.

It should be stated that the samples for the purpose of this investigation were taken from districts ranging from sea-level up to an altitude of 1,100 feet.

The chemical composition of bog-hay.

As far as can be ascertained from reference to agricultural literature, apart from some work carried out on the continent,[3] little information is available with regard to the chemical composition of bog-hay. It is, however, generally recognised to be deficient in ash, and as the importance of the mineral constituents of foodstuffs has of late been receiving greater attention, the principal constituents of the ash were determined in the hays.

The present investigation was undertaken with the object of determining :—

1. The chemical composition of bog-hays grown in various localities in Wales with special reference to some of their mineral constituents.
2. The effect of the application of manures on the chemical composition of this type of hay.

The samples are last seasons hay (1925), being obtained at harvest time, and since the time of cutting varies from district to district, the samples represent bog-hay of different degrees of maturity. The spring and early summer being fairly dry, the seasonal conditions were probably more favourable for the growth of the better type of grasses in these situations.

In addition to the constituents usually estimated in a foodstuff, the percentage of true protein, phosphoric acid, lime, oxides of iron and chlorine was also determined.

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[3] "Molinia Hay; its composition and feeding value". F. Honcamp and O. Nolte. *Landw. Vers. Stn.* 93, 1917.

The chemical composition of bog-hay in which one or two types of vegetation are prevalent in the hay.

The influence that the "type of vegetation" has on the chemical composition is shown in Table A (appendix), from which the following average results, shown in Table I, have been abstracted. These samples, though containing small amounts of other grasses, may be taken to represent the hay of Molinia, Nardus, sedges and cotton sedges, sheep's fescue, tufted scirpus, rushes and bent. (The botanical analysis is given in Table A, appendix). Typical bog-hay, as mentioned above, does not contain a large amount of rushes, bent, nor sheep's fescue, though a small amount is often present. On the other hand, farmers often refer to hay containing practically 90% of rushes as bog-hay, while other samples may contain over 50% of bent.

Table I gives the average chemical composition of the dry matter of the seven types of hay, as well as the composition of a sample of ordinary meadow hay for comparison.[4]

TABLE I.

TYPE OF HAY.	*Molinia.*	*Nardus*	*Sedges and Cotton Sedges.*	*Sheep's Fescue.*	*Tufted Scirpus*	*Rushes*	*Bent.*	*Meadow Hay.*
Ether Extract	2.48	2.26	2.09	2.50	2.74	1.89	2.12	2.50
Crude Protein	11.18	8.40	10.72	10.29	8.37	7.51	10.96	10.31
True Protein	9.99	8.01	10.04	9.21	7.93	7.00	8.68	8.79
Fibre	30.80	31.03	30.71	22.62	28.72	39.28	31.41	25.03
Ash	3.89	3.98	3.96	4.01	3.36	5.19	4.63	7.34
Sol. Carbohydrates	51.65	54.33	52.52	50.58	56.81	45.83	50.88	54.82
Silica (SiO_2)	0.84	1.68	1.49	0.60	1.30	1.02	0.88	0.58
Phosphoric Acid (P_2O_5)..	0.21	0.24	0.16	0.25	0.18	0.34	0.31	0.46
Lime (CaO)	0.362	0.245	0.564	0.492	0.404	0.595	0.731	1.66
Iron (Fe_2O_3)	0.021	0.040	0.018	0.020	0.029	0.017	0.019	0.046
Chlorine (Cl)	0.289	0.172	0.190	0.274	0.172	0.852	0.735	0.644
Silica-free Ash	3.05	2.30	2.47	3.41	2.06	4.47	3.75	6.76

These results show fairly wide variation in the percentage of the principal constituents determined. Of the seven types of hay, those made up largely of Molinia, sedges, sheep's fescue and bent, respectively, are seen to be superior in protein content to the remainder. The Molinia hay has the highest percentage of protein, while the hay composed of rushes is the lowest. A comparison of the ratio of true to crude protein indicates that some of the hays were much more mature than others.

The fibre content shows the hay mainly composed of rushes to be distinctly highest in this constituent, the hay in which tufted scirpus is dominant being lowest. The difference between the fibre content of the remainder is only slight.

[4] A more detailed comparison of Bog-hay with Meadow Hay is given on page 143.

The hays composed of the more typical bog-hay vegetation, *i.e.*, Molinia, Nardus, sedges and tufted scirpus, are seen to be lower in ash than the hays of bent, rushes and sheep's fescue. On comparing the percentage of ash in the former with that of ordinary meadow hay, which contains about 7%, it is seen that the general belief that bog-hay is deficient in ash is well justified. When the silica-free ash is taken as a basis of comparison, which from the point of view of nutrition is probably a better criterion, the more typical bog-hays are found to contain less than 3%, while the hay largely composed of rushes is the only one to contain 4%.

The percentage of ash in itself, however, gives little information as to the relative amounts of the different mineral constituents that it contains, as seen on comparing the hays of Nardus and sedges. Although the percentage of ash is very similar in both hays, the former contains one and a half times as much phosphoric acid as the latter, while the latter contains twice as much lime.

The relative amount of the various mineral constituents present indicates a distinct difference in the nature of the ash of the seven types of hay. The percentage of phosphoric acid is strikingly low in the hays in which cotton sedges and tufted scirpus predominate, while it is highest in the hays largely composed of rushes and bent. Molinia and Nardus, although richer in phosphoric acid than cotton sedges and tufted scirpus, are on the other hand distinctly inferior to all the other hays in their lime content, Nardus being the poorest of the seven in this constituent. As in the case of the phosphoric acid, the lime content of the rushes and bent samples is also superior to that of the other types. It is of interest to note that the ratio of phosphoric acid to lime varies from 1 : 1 in Nardus hay, where it is highest, to 1 : 35 in the sedges hay, in which the ratio is lowest.

The more typical bog-herbage is also poor in iron and chlorine content. The hays in which rushes and bent are dominant contain nearly five times as much chlorine as the other types, Nardus, tufted scirpus and sedges being strikingly low.

The results clearly indicate that the type of vegetation prevalent in the hay has a pronounced effect on its chemical composition.

The chemical composition of bog-hay in which several types of vegetation are present to a considerable extent.

When the herbage is composed of a "number of varieties" present in appreciable amounts the variation in chemical com-

TABLE IV.

	(1) *Sample* (14). *Table B.* *Received basic slag,* *Spring*, 1924.	(2) *Sample* (15). *Table B.* *Received basic slag about* 1914.	(3) *Sample* (6). *Table A.* *Sample from same area but unmanured*
Crude Protein ...	11.38	13.06	11.14
True Protein ...	10.75	12.44	10.78
Fibre	33.07	31.84	30.49
Silica-free Ash ...	3.10	2.09	2.28
Phosphoric Acid ...	0.31	0.24	0.17
Lime	0.583	0.443	0.494
Chlorine	0.053	0.085	0.136

The botanical composition of samples (1) and (2) is very similar, sample (3) containing less Molinia and more sedges than the others. The three hays were cut on August 8th, 1925, the manurial treatment being as described above. The results indicate that the application of slag in 1924 had little effect on the protein content but increased the silica-free ash, phosphoric acid and lime appreciably, the chlorine being depressed. Sample (2) had a distinctly higher protein content than the others, but its low ash content suggests that the manurial effect had finished. The phosphoric acid content of sample (2) is higher than that of sample (3), but the latter is richer in lime and chlorine, this being probably due to the fact that it contained more sedges than the former, this type being poor in phosphoric acid and rich in lime. From these results it appears that the phosphoric acid content was more affected by the slag applied in 1924 than the other ash constituents.

APPENDIX A.

The botanical composition of the samples of hay shown in Table A (Appendix) :—

I. Molinia Hays.

Sample (1) *from Glandovey.*

Molinia	99%
Bog Ashphodel	1%

Sample (2) *from Trawsfynydd.*

Molinia	80—90%
Bent	5%
Sheep's fescue ...	5—10%

II. Nardus Hays.

Sample (3) *from Bala.*

Bent	10%
Nardus	80%
Bilberry	5%
Moss	5%

Sample (4) *from Mynachdy Gwyn Clynnog.*

Bent	10%
Nardus	50—60%
Sweet vernal	5%
Heath grass	20—25%
Rush	5—10%

III. Sedges and Cotton Sedges.

Sample (5) *from Lleyn.*

Molinia	5%
Sedges and cotton sedges	90%
Rushes	Trace.
Horsetail	Trace.

Sample (6) *from Lleyn.*

Molinia	20%
Bog Ashphodel	10%
Cotton sedges	60%
Miscellaneous	10%

IV. Sheep's Fescue Hay.

Sample (7) *from Bala.*

Bent	20%
Sheep's fescue	60%
Wavy hair-grass	10%
Miscellaneous	10%

Sample (8) *from Berthddu, Trawsfynydd.*

Molinia	10—15%
Bent	15—20%
Nardus	5—10%
Sweet vernal	5—10%
Sheep's fescue	50%

V. Tufted Scirpus Hays.

Sample (9) *from Dolbenmaen, Hendre Orion.*

Sedges	5—10%
Cotton sedges	Trace.
Tufted scirpus	90%
Miscellaneous Molinia Sheep's fescue Ling Luzula Scabious Moss (Sphagnum and Polytrichum)	Trace.

Sample (10) *from Llanfihangel-y-Pennant.*

Molinia	5—10%
Sedges	10%
Tufted scirpus	60—70%
Miscellaneous	5%

VI. Rushes.

Sample (11) *from Cachowell, Anglesey.*

Bent	5%
Rushes	90%
Miscellaneous	5%

Sample (12) *From Mount Hazel, Penrhyndeudraeth.*

Bent	10%
Rough stalked meadow grass	5%
Rushes	85%

VII. Bent.

Sample (13), *Pyllauduon, Tregaron.*

Bent	80—90%
Sweet vernal	5—10%
Yorkshire fog	Trace.

Sample (14), *Llanuwchllyn.*

Bent	40—50%
Sweet vernal	5%
Crested dogstail	5%
Rushes	20%
Yorkshire fog	5%
Devil's bit	5%
Knapweed	5%

APPENDIX B.

Botanical composition of the samples shown in Table B :—

Sample (1) *from Tyddyn Mawr, Trawsfynydd.*

Molinia	10%
Nardus	40—50%
Sedges (Carex)	10%
Cotton sedges (Eriophorum)	10%
Sweet vernal	5—10%
Yorkshire fog	5%
Rush (Juncus)	5%
Yellow rattle Lotus major Scabious Polytrichum	Trace.

Sample (2) *from Cefngallgwm, Trawsfynydd.*

Molinia	10%
Bent	5—10%
Nardus	20%
Sedges	20%
Sweet vernal	5%
Yorkshire fog	Trace.
Fine-leaved fescue	30%
Luzula Tormentil Sphagnum	5%

Sample (3) *from Garnedd Lwyd, Arenig.*

Molinia	70%
Nardus	10%
Sheep's fescue	5%
Sweet vernal	
Yorkshire fog	
Luzula	10%
Tormentil	
Sphagnum	
Scabious	

Sample (4) *from Garnedd Lwyd, Arenig.*

Molinia	15—20%
Bent	20%
Nardus	5—10%
Sweet vernal	5—10%
Yorkshire fog	5%
Rushes (Juncus) ...	40—50%
Luzula	Traces.
Scabious	

Sample (5) *from Cefnbodig, Bala.*

Molinia	70%
Bent	25%
Sedges	
Wavy-hair grass	5%
Rushes	

Sample (6) *from Tyddyn-du, Parc.*

Molinia	20%
Bent	20%
Nardus	30%
Sweet vernal	5%
Wavy hair-grass	10%
Rushes	5%
Miscellaneous	10%

Sample (7) *from Parc, Bala.*

Bent	10%
Nardus	30%
Sedges	5%
Sweet vernal	5%
Wavy hair-grass	40%
Rush (Juncus)	5%
Meadow vetchling	Trace.
Tormentil	

Sample (8) *from Parc, Bala.*

Sedges	40%
Cotton sedges	10%
Fine-leaved fescue ...	10%
Rushes	30%

Sample (9) *from Mynachdy-Gwyn, Clynnog.*

Molinia	30—40%
Bent	20—30%
Nardus	20—30%
Sedges	10—20%
Sweet vernal	Trace.

Sample (10) *from Hengwm, Clynnog.*

Bent	10%
Nardus	30—40%
Cotton sedges ...	5%
Sweet vernal	5%
Heath grass (Triodia) ...	5%
Rush (Juncus) ...	20—30%
Yorkshire fog ...	Trace.
Luzula	5%
Tormentil	Trace.
Sphagnum moss ...	5%

Sample (11) *from Berth Eos, Dolwyddelen.*

Bent	10%
Nardus	50%
Sedges	5%
Sweet vernal	5%
Fine-leaved fescue ...	25%
Wavy hair-grass	5%

Sample (12) *from Nant-y-frwydr.*

Nardus	50%
Sedges	10%
Heath grass	10%
Yorkshire fog	10%
Miscellaneous	20%

Sample (13) *from Mount Hazel* (B)

Molinia	30%
Nardus	20%
Sedges and Cotton sedges ...	10%
Wavy hair-grass	10%
Rushes	20%
Miscellaneous	10%

Sample (14) (A) *from Lleyn.*

Molinia	50%
Bent	5%
Sedges	40%
Fine-leaved fescue ...	Trace.
Bog Ashphodel	5%

Sample (15) *from Lleyn.*

Molinia	50%
Sedges	40%
Bog Ashphodel	10%

TABLE A.

Showing the Chemical Composition (dry matter) of Bog Hays composed mainly of one type of Vegetation.

TYPE OF HAY :—	*Molinia Hays.* 1	2	*Nardus Hays.* 3	4	*Sedges and Cotton Sedges.* 5	6	*Sheep's Fescue.* 7	8	*Tufted Scirpus (Caespitosus).* 9	10	*Rushes.* 11	12	*Agrostis (Bent).* 13	14
Ether Extract	2.13	2.83	2.00	2.53	1.65	2.54	2.53	2.48	2.93	2.55	2.07	1.71	2.25	1.99
Crude Protein	11.81	10.56	7.75	9.06	10.31	11.14	10.12	10.47	8.75	7.99	6.81	8.22	11.60	10.33
True Protein	11.25	8.73	7.50	8.54	9.31	10.78	10.00	8.43	8.43	7.43	6.31	7.69	8.90	8.47
Fibre	30.48	31.12	30.38	32.73	30.93	30.49	34.80	30.45	28.03	29.41	38.82	39.74	29.28	33.55
Ash	3.21	4.58	4.00	3.97	4.77	3.16	3.00	5.02	3.43	3.29	5.90	5.08	4.39	4.88
Sol. Carbohydrates	52.37	50.91	55.87	51.71	52.34	52.67	49.55	51.58	56.86	56.76	46.40	45.25	52.48	49.25
Silica (SiO_2)	0.75	0.93	2.00	1.37	2.10	0.88	0.37	0.83	1.33	1.27	0.89	1.16	1.10	0.67
Phosphoric Acid (P_2O_5)	0.21	0.21	0.20	0.28	0.16	0.17	0.24	0.26	0.18	0.19	0.35	0.33	0.41	0.28
Lime (CaO)	0.294	0.430	0.256	0 234	0.635	0.491	0.359	0.625	0.415	0.394	0.621	0.569	0.505	0.962
Oxides of Iron (Fe_2O_3)	0.018	0.024	0.057	0.023	0.020	0.017	0.017	0.024	0.035	0.024	0.017	0.017	0.015	0.023
Chlorine (Cl)	0.175	0.103	0.094	0.250	0.245	0.136	0.253	0.296	0.145	0.198	0.952	0.751	0.868	0 603
Nitrogen (N)	1.89	1.69	1.24	1.45	1.65	1.78	1.62	1.67	1.40	1.28	1.09	1.32	1.85	1.66

TABLE B.

Showing the Chemical Composition (dry matter) of Bog Hays composed of several types of Vegetation.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ether Extract	2.60	3.20	2.45	2.13	2.24	2.45	2.20	2.85	2.88	2.00	2.25	2.90	2.33	2.06	2.42
Crude Protein	10.61	11.00	10.79	10.69	11.56	10.00	10.88	10.00	11.62	9.00	9.87	9.75	10.00	11.38	13.06
True Protein	9.51	9.25	8.78	8.75	11.05	9.31	9.50	9.78	10.94	8.62	9.07	9.13	9.18	10.75	12.44
Fibre	29.95	31.08	30.38	29.90	33.18	30.20	33.32	32.60	29.03	30.28	34.65	31.93	33.55	33.07	31.84
Ash	4.04	4.62	4.14	5.22	2.99	3.70	2.99	5.50	3.55	4.52	3.47	4.60	4.90	4.06	3.02
Sol. Carbohydrates	52.50	50.10	52.24	52.06	50.03	53.65	50.61	49.05	52.92	54.20	49.76	50.82	49.22	49.43	49.66
Silica (SiO_2)	1.22	2.43	0.63	1.63	0.40	0.65	0.20	0.90	0.92	1.92	1.05	1.58	2.49	0.96	0.93
Phosphoric Acid (P_2O_5)	0.27	0.22	0.28	0.27	0.20	0.24	0.32	0.27	0.31	0.26	0.22	0.23	0.21	0.31	0.24
Lime (CaO)	0.460	0.522	0.650	0.364	0.415	0.635	0.653	0.453	0.290	0.262	0.549	0.583	0.378	0.583	0.443
Oxides of Iron (Fe_2O_3)	0.021	0.024	0.029	0.017	0.017	0.025	0.023	0.023	0.035	0.023	0.025	0.029	0.019	0.017	0.017
Chlorine (Cl)	0.423	0.299	0.210	0.709	0.201	0.310	0.348	0.475	0.145	0.370	0.170	0.241	0.289	0.053	0.085
Nitrogen (N)	1.74	1.76	1.75	1.71	1.85	1.60	1.74	1.60	1.86	1.44	1.58	1.56	1.60	1.82	2.09

The influence of different phosphatic manures on the chemical composition of bog-hay.

To investigate the effect of the application of fertilisers on the chemical composition of bog-hay advantage was taken of the scheme of experiments organised by the Chemistry Committee of the Agricultural Education Association in 1919. The object of these experiments was " to ascertain the effect and relative manurial value of three types of basic slag and mineral phosphates." In those districts which are largely dependent upon bog-hay for their fodder it is of considerable economic importance that efforts be made to produce more herbage of a better quality on these areas. Improvement has been largely confined in the past to surface drainage, basic slag and farmyard manure being only applied to a very limited extent. Surface drainage, provided the ditches are kept open and effective, greatly reduces the water content of the soil in spring, and this is followed by a more vigorous growth of a better type of herbage.

Two series of five experimental plots were laid down by the County Agricultural Organiser for Cardiganshire, in the autumn of 1920, on a typical bog-area (Tregaron bog), which had a considerable depth of peat and a clay subsoil. Prior to laying down the plots samples of the soil and subsoil were taken from the site of the proposed plots, and these on analysis were found to have the following composition :—

	Soil.	*Subsoil.*
Moisture	11.70 ...	10.02
Organic matter ...	50.04 ...	49.90
Nitrogen	1.64 ...	—
Calcium carbonate ...	*Nil.* ...	—

Forty-eight hours digestion with HCL.

	%
Potash (K_2O)	0.453
Phosphoric acid (P_2O_5)	0.128
Calcium oxide (CaO)	0.160
Magnesium oxide (MgO)	0.270

The following details as to the manures applied and their analysis are taken from the directions and information issued by the Committee :—

1. High grade slag. (Open hearth Talbot) comparable with Bessemer.
2. Open hearth high soluble slag.
3. Open hearth low soluble slag.
4. Gafsa mineral phosphate.

All the manures were applied at the rate of 200 lb. P_2O_5 per acre.

Analysis of Manures.

Percentage of	*BASIC SLAG.*			*Gafsa Mineral Phosphate.*
	High grade Bessemer. O.H.	*Open Hearth.*		
		High Soluble.	*Low Soluble.*	
Total Phosphate. Expressed as				
(1) P_2O_5	17·10	10·38	10·36	27·08
(2) $Ca_3P_2O_8$	34·34	22·67	22·62	59·14
Citric Soluble Phosphate. Expressed as				
(1) P_2O_5	13·81	9·72	2·81	—
(2) $Ca_3P_2O_8$	30·16	21·23	6·14	—
% Citric Solubility.	80·7	91·0	27·2	—
Fineness.	80·6	83·0	86·0	—

The plots had an eastern aspect and were surface drained, the drainage being better on the upper series than on the lower plots.

Previous to the application of the manures in the autumn of 1920 the plots had been annually cut for hay, but received no manurial treatment. A sample of the hay harvested from the site of the proposed plots was found to be composed mainly of jointed rush and Molinia, the sample in addition containing floating meadow grass, devil's bit, rib grass, saw-wort, knapweed, common rush, bent grass, sweet vernal, crested dogstail and wood-rush.

The improvement in the quality of the herbage, subsequent to the application of basic slag and mineral phosphates, is shown by the botanical composition of the samples of hay received for analysis. Briefly summarised, this improvement was indicated by the appearance of wild white clover on some of the plots, while the amount of sweet vernal, crested dogstail, Yorkshire fog and sheep's fescue was increased, the control plot containing more jointed rush and bent. As to the individual effect of the fertilisers experimented with, high grade Bessemer's slag and high soluble open-hearth slag seem to have encouraged the growth of wild white clover more than the less soluble low grade slag and mineral phosphates.

The chemical composition of the hay harvested from the upper and lower series of plots in 1923, two years subsequent to the application of the phosphates, is given in Table C (Appendix). A comparison of the upper and lower manurial plots shows that

the percentage of ash is uniformly higher on the upper plots than on the lower. The average chemical composition of the hays (dry matter) of the five duplicate plots is given in Table V below :—

TABLE V.

	Basic Slag.				
	High Grade. High Soluble.	*Low Grade.*		*Gafsa Mineral Phosphate*	*No Manure. Control.*
		High Soluble.	*Low Soluble.*		
	Plot (1)	*Plot* (2)	*Plot* (3)	*Plot* (4)	*Plot* (5)
Moisture	9.83	10.39	10.50	10.26	9.90
Ether Extract	3.32	3.01	2.66	2.49	2.60
Crude Protein	13.82	12.55	11.57	12.18	11.79
True Protein	11.92	10.81	10.07	10.26	9.36
Fibre	28.60	32.43	32.55	30.28	31.25
Ash	5.01	5.05	5.49	5.18	4.22
Sol. Carbohydrates	49.25	46.96	47.73	49.87	50.13
Silica (SiO_2)	1.34	1.51	1.12	1.41	0.99
Phosphoric Acid (P_2O_5) ..	0.593	0.644	0.491	0.639	0.427
Lime (CaO)	0.881	0.709	0.853	0.746	0.544
Oxides of Iron (Fe_2O_3) ..	0.021	0.016	0.017	0.016	0.014
Chlorine	1.112	0.972	1.016	0.917	0.882
Nitrogen	2.21	2.00	1.85	1.95	1.88
Silica-free Ash	3.67	3.54	4.37	3.77	3.23

The phosphatic manures applied to each plot is as indicated above. The results show that the manurial plots, with the exception of plot (3), are richer in protein than the control plot, this increase in protein content being most pronounced on plot (1), which received high grade high soluble slag, while plot (2) also shows a distinct superiority. The botanical analysis confirms the above as the herbage of plots (1) and (2) was superior in quality and contained some wild white clover, which was not present on plot (3), the amount of crested dogstail on this latter plot being also smaller than on the other manurial plots. The true protein on the other hand is higher in all the manured hays than in the unmanured, though plot (3) is poorer in this constituent than the others.

An examination of the fibre content of the hays shows that plots (1) and (4) are lower than the control plot, while plots (2) and (3) are higher. The application of phosphatic manures has increased the ash content of all the hays, the most distinct increase being shown by the plot that received low grade low soluble slag. The variation between the other manurial plots is very slight. The silica-free ash content also shows the superiority of the manurial plots over the control plot.

A comparison of the mineral content of the manured and unmanured hays is of interest in that it brings out clearly the enhanced value of the manured hays as shown by the percentage

of phosphoric acid, lime and chlorine. Although the hay from plot (3) is the highest in ash this manure appears to have the least effect on the phosphoric acid content, showing that ash determination in itself is no guidance to the relative amounts of the various mineral constituents present. The low grade high soluble slag, on the other hand, had the most distinct influence on the phosphoric acid, while plots (1) and (4) are only slightly lower.

The lime content of the hay of plot (3), however, comes next to plot (1), which is the richest, so that the low grade low soluble slag appears to have influenced the lime content more than the other ash constituents. Further, basic slag generally increased the percentage of lime more than the mineral phosphates.

The iron and chlorine content also shows an increase over the control plot, plot (1) being the highest in both iron and chlorine, while plot (3) is only slightly lower. The mineral phosphates had the least effect on the chlorine content.

The results indicate a distinct improvement in the quality of the herbage subsequent to the application of phosphatic manures, this improvement being very marked in the case of the ash and its principal constituents.

Samples of the hay harvested from these plots were again taken in 1924, but the time of cutting was about a fortnight later than in the previous year. The chemical composition of the 1924 crop is given in Table D (appendix), this being the third hay crop taken off these plots subsequent to the application of the phosphatic manures. On comparing the results for the upper and

TABLE VI.

Results expressed as percentage of dry matter.

	Basic Slag.				
	High Grade. High Soluble.	*Low Grade.*			
		High Soluble.	*Low Soluble.*	*Gafsa Mineral Phosphate.*	*No Manure. Control.*
No. of Plots—	*Plot* (1)	*Plot* (2)	*Plot* (3)	*Plot* (4)	*Plot* (5)
Moisture	15.00	14.56	14.00	14.64	14.54
Ether Extract	2.78	2.64	2.61	2.68	2.20
Crude Protein	10.02	10.26	9.51	10.01	10.03
True Protein	8.75	9.25	8.58	9.32	9.36
Fibre	34.56	34.68	35.74	33.83	33.05
Ash	4.79	4.81	5.01	5.30	4.51
Sol. Carbohydrates	47.85	47.61	47.13	48.18	49.61
Silica (SiO_2)	0.75	0.76	0.62	0.73	0.53
Phosphoric Acid (P_2O_5)	0.29	0.27	0.35	0.36	0.24
Lime (CaO)	0.697	0.626	0.623	0.753	0.394
Oxides of Iron (Fe_2O_3)	0.021	0.019	0.018	0.021	0.018
Chlorine	0.665	0.630	0.725	0.700	0.607
Nitrogen	1.60	1.64	1.52	1.60	1.60
Silica-free Ash	4.04	4.05	4.39	4.57	3.98

lower series of plots it is seen that the upper plots are again superior in chemical composition, and since the drainage of the lower series was poorer than on the upper plots, this suggests that fertilisers have a better and more prolonged effect on the better drained portions. Even the lower plots, however, show that the manurial effect is still evident in the third harvest year. The increase in ash shown in the 1923 hay appears to be maintained by the upper series in the 1924 hay crop. The average chemical composition of the hay from the duplicate plots for 1924 is shown in Table VI.

TABLE C. (Appendix).

Showing the Analysis of the (dry matter) Hays harvested from the Phosphate Plots in 1923.

UPPER PLOTS.

	Basic Slag.				
	High Grade. High Soluble	*Low Grade.*		*Gafsa Mineral Phosphate.*	*No Manure. Control.*
		High Soluble.	*Low Soluble.*		
	Plot (1)	*Plot* (2)	*Plot* (3)	*Plot* (4)	*Plot* (5)
Moisture	10.25	10.85	10.50	10.25	9.00
Ether Extract	3.51	2.47	2.14	2.56	2.25
Crude Protein	13.92	12.83	11.17	12.46	11.60
True Protein	11.91	10.37	9.03	10.08	8.92
Fibre	28.74	31.76	33.21	30.25	29.28
Ash	5.29	5.50	5.58	5.29	4.39
Sol. Carbohydrates	48.54	47.44	47.90	49.44	52.48
Silica (SiO_2)	1.29	1.60	1.13	1.39	1.10
Phosphoric Acid (P_2O_5)	0.579	0.629	0.480	0.679	0.406
Lime (CaO)	0.958	0.706	0.860	0.814	0.505
Oxides of Iron (Fe_2O_3)	0.021	0.017	0.021	0.017	0.015
Chlorine ((Cl)	1.069	1.054	1.016	0.991	0.868
Nitrogen (N)	2.23	2.05	1.79	1.99	1.85

LOWER PLOTS.

(Duplicate Plots to above.)

	Basic Slag.				
	High Grade. High Soluble.	*Low Grade.*		*Gafsa Mineral Phosphate.*	*No Manure. Control.*
		High Soluble.	*Low Soluble.*		
	Plot (1)	*Plot* (2)	*Plot* (3)	*Plot* (4)	*Plot* (5)
Moisture	9.41	9.94	10.50	10.28	10.80
Ether Extract	3.14	3.56	3.18	2.02	2.97
Crude Protein	13.72	12.28	11.97	11.91	11.98
True Protein	11.93	11.25	11.11	10.44	9.81
Fibre	28.47	33.11	31.89	30.31	33.23
Ash	4.74	4.61	5.41	5.07	4.05
Sol. Carbohydrates	49.93	46.44	47.55	50.69	47.77
Silica (SiO_2)	1.40	1.42	1.11	1.44	0.89
Phosphoric Acid (P_2O_5)	0.607	0.659	0.502	0.602	0.448
Lime (CaO)	0.805	0.713	0.847	0.679	0.584
Oxides of Iron (Fe_2O_3)	0.022	0.014	0.013	0.015	0.012
Chlorine (Cl)	1.155	0.889	1.016	0.902	0.896
Nitrogen	2.20	1.96	1.92	1.91	1.92

N.B.—The low moisture content is probably due to the fact that the samples were kept for some time before they were analysed.

From these results it is seen that the difference between the protein and fibre content of the hays from the five plots is only slight, but the total and silica-free ash is higher in the manured hays. The hays from plots (8) and (4) are richer than all the others in silica-free ash, phosphoric acid and chlorine content, while plot (4) has also the highest percentage of lime. This suggests that the low soluble slag and the mineral phosphates, though slightly inferior to the high soluble slags in the second harvest year, are more prolonged in their effect on the chemical composition of the herbage. Plots (1) and (2), however, are considerably richer in lime than the control plot, while their phosphoric acid and chlorine content is also higher.

TABLE D. (Appendix).

Showing the Chemical Composition (dry matter) of the Hays harvested from the Phosphate Plots in 1924.

UPPER PLOTS.

	Basic Slag				
	High Grade. High Soluble.	*Low Grade.*		*Gafsa Mineral Phosphate*	*No Manure. Control.*
		High Soluble	*Low Soluble*		
	Plot (1)	*Plot* (2)	*Plot* (3)	*Plot* (4)	*Plot* (5)
Moisture	14.99	14.86	13.21	14.61	14 00
Ether Extract	3.05	2.91	2.30	2.65	2.39
Crude Protein	10.34	10.52	9.40	10.64	10.07
True Protein	9.38	9.12	8.45	10.00	9.38
Fibre	34.68	35.41	36.30	32.80	32.6[illegible]
Ash	5.23	5.37	5.58	6.00	5.02
Sol. Carbohydrates	46.40	45.79	46.12	47.91	19.87
Silica (SiO_2)	0.74	0.86	0.60	0.68	0.49
Phosphoric Acid (P_2O_5)	0.30	0.29	0.35	0.41	0.27
Lime (CaO)	0.812	0.803	0.695	0.863	0.439
Oxides of Iron (Fe_2O_3)	0.023	0.020	0.020	0.025	0.019
Chlorine (Cl)	0.861	0.857	0.900	0.875	0.700
Nitrogen	1.70	1.68	1.50	1.70	1.61

LOWER PLOTS.

(Duplicate Plots to above).

	Basic Slag.				
	High Grade. High Soluble.	*Low Grade.*		*Gafsa Mineral Phosphate.*	*No Manure. Control.*
		High Soluble.	*Low Soluble.*		
	Plot (1)	*Plot* (2)	*Plot* (3)	*Plot* (4)	*Plot* (5)
Moisture	15.01	11.33	14.80	14.68	15.09
Ether Extract	2.51	2.38	2.93	2.71	2.02
Crude Protein	9.40	10.00	9.62	9.38	10.00
True Protein	8.13	9.38	8.70	8.64	9.34
Fibre	34.45	33.95	35.18	34.85	34.65
Ash	4.35	4.25	4.45	4.61	4.01
Sol. Carbohydrates	49.29	49.42	47.82	48.45	49.32
Silica	0.76	0.66	0.64	0.78	0.56
Phosphoric Acid (P_2O_5)	0.29	0.25	0.36	0.32	0.22
Lime (CaO)	0.582	0.450	0.550	0.642	0.350
Oxides of Iron (Fe_2O_3)	0.019	0.018	0.017	0.017	0.017
Chlorine (Cl)	0.469	0.403	0.550	0.526	0.514
Nitrogen	1.50	1.60	1.54	1.50	1.60

Since bog-hay, as indicated previously, is deficient in silica-free ash, it is of interest to note that the slags and mineral phosphates applied considerably increased the mineral constituents of the hays, both in the second and third harvest year; the mineral phosphates being superior to the basic slags in the third year.

These results indicate that under the conditions of the experiment, namely, sour peaty soils in regions of fairly high rainfall, that the influence of the gafsa phosphate on the chemical composition of the herbage is on the whole quite as pronounced as that of the more soluble basic slags. Such a conclusion, which is supported by the Essex experiments,[6] is of special interest, being that under normal conditions gafsa phosphate is the cheapest form of phosphatic manure.

The effect of various mixtures of artificial manures on bog-hay.

Advantage was taken of the following experiment conducted in Merionethshire to compare the effect of different mixtures of artificial manures on the yield and chemical composition of the natural herbage of peaty soils. The plots were laid out by the County Staff on land that had not been previously manured, surface drainage being the only means that had been adopted to improve the land. The drainage was fairly good, though there was a depth of peat of several feet—the site of the plots being a typical bog-area. A soil sample taken at the time of laying down the plots was found to contain 75% of organic matter.

In March, 1925, the following fertilisers were applied to the different plots :—

Plot (1). No manure applied.
Plot (2). Sulphate of ammonia and kainit.
Plot (3). Sulphate of ammonia and basic slag.
Plot (4). Kainit and basic slag.
Plot (5). Sulphate of ammonia, basic slag and kainit.

The dressing applied was at the rate of 20 lb. of nitrogen, 40 lb. of phosphoric acid, and 20 lb. of potash per acre. The slag used was Bilston 30% total phosphate.

All the plots were cut for hay on July 8th, 1925. As the interval between the application of the fertilisers and the time of cutting the hay was short, the full effect of the fertilisers would not be shown in the first hay-crop.

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6 " Basic Slags and Rock Phosphates ". G. S. Robertson. *Cambridge Agricultural Monographs*, p. 46. Also *Pfeiffer Inter. Institute of Agriculture Bulletin*, Sept., 1913, p. 1316.

The botanical composition of the hays shows the herbage of the manured plots—though varying among themselves—to be superior to that of the control plot. The normal herbage growing on this area was composed mainly of molinia, sedges and bent, while rushes and horsetail were also present. Subsequent to the application of the artificial manures the herbage of plots (2) and (3) showed an appreciable increase in the amount of sweet vernal present, especially so in the case of the former plot, which contained approximately 20% of this species, while Molinia, sedges and bent were less prevalent. The herbage of plot (4) was not affected to the same extent by its manurial dressing, though there was a slight increase in the amount of sweet vernal, the horsetail being suppressed. The most beneficial effect on the type of vegetation was shown in the hay of plot (5)—which received a complete dressing of fertilisers—sweet vernal forming 25% of this hay, while about 50% of bent grass was also present. It is interesting to note that the slagged plots showed an appreciable increase of wild white clover compared with plot (2) and the control plot. On the plots receiving no slag the clover plants were small and weak, while on the slagged plots the plants colonised and spread. The horsetail was also markedly suppressed on all the manured plots.

The chemical composition of the hay harvested from the five plots is given in Table VII below :—

TABLE VII.

Showing the effect of different manurial treatments on the Chemical Composition (dry matter) of Bog Hay.

	Plot (1) *No. Manure (Control).*	*Plot* (2) *Kainit plus Sulphate of Ammonia.*	*Plot* (3) *Basic Slag plus Sulphate of Ammonia.*	*Plot* (4) *Basic Slag plus Kainit.*	*Plot* (5) *Basic Slag plus Kainit plus Sulphate of Ammonia.*
Ether Extract	2.01	2.45	2.21	2.48	2.43
Crude Protein	11.00	11.56	11.51	13.38	11.13
True Protein	10.56	10.49	10.28	12.50	10.19
Fibre	31.93	33.80	34.78	34.53	34.89
Ash	5.35	5.50	5.93	6.50	6.48
Sol. Carbohydrates	49.40	46.69	45.57	43.11	45.07
Silica (SiO_2)	0.90	0.53	0.58	0.55	0.60
Phosphoric Acid (P_2O_5)	0.28	0.42	0.51	0.44	0.46
Lime (CaO)	0.610	0.667	0.670	0.812	0.861
Oxides of Iron (Fe_2O_3)	0.023	0.023	0.023	0.023	0.023
Chlorine (Cl)	0.564	0.726	0.726	0.789	0.822
Nitrogen (N)	1.76	1.85	1.84	2.14	1.78
Silica—free Ash	4.45	4.97	5.35	5.95	5.88

YIELD OF HAY. (*Calculated per Acre.)

	Plot (1) *(Control).* T. c. lb.	*Plot* (2) *(K.N.)* T. c. lb.	*Plot* (3) *(P.N.)* T. c. lb.	*Plot* (4) *(K.P.)* T. c. lb.	*Plot* (5) *(K.P. and N.)* T. c. lb.
Yield per Acre	0 11 38	0 13 56	0 15 54	0 15 14	1 1 08

* These figures were supplied by Mr. M. Griffith, Agricultural Organiser for Merionethshire.

The yield of hay obtained from the manured plots was also higher than that of the control plot. The variation in yield, however, shows that some mixtures of artificial manures applied were distinctly superior to others. Plot (2), receiving no slag, was only slightly better than the control plot, but plots (3) and (4) gave a distinct increase in yield, the former plot being slightly higher. The complete dressing of fertilisers, on the other hand, gave a distinct increase in yield over *all* the plots, the yield from this plot being double that of the unmanured plot.

The distinct increase in yield obtained from plot (5) is of importance, as at present there is a tendency among farmers to concentrate more on the improvement and increasing the hay yield of the poorer type of arable land, the bog-hay areas being neglected. These results show that with suitable manuring profitable returns can be obtained from these bog areas.

A comparison of the protein content of these hays shows that the hay harvested from plot (4) (slag and kainit) is distinctly superior to all the others in this constituent. The produce from the other manured plots is only slightly richer in crude protein than the hay from the control plot, while the true protein content of all these hays, with the exception of plot (4), is slightly inferior to that of the unmanured plot. The superiority in protein of the hay from plot (4) is rather surprising, as all the other manured plots received nitrogenous manure which was *not* included in the dressing of this plot.[7] The preponderance of molinia—a species shown in Table I to be fairly rich in protein—and the presence of a small amount of wild white clover may have contributed towards the high protein content of this hay. On the other hand, the unfavourable conditions for nitrification would militate against any increase in protein which the application of ammonium sulphate might produce under normal circumstances.

The ratio of true to crude protein shows the hay from the control plot to be slightly more mature than the others.[8] The fibre content of the manured hays is very similar and appreciably higher than that of the unmanured hay, which suggests that hay from land that has been manured should be cut early.

Manuring has also increased the percentage of ash in the hay, all the hays from the manured plots being richer than that of the control plot. Of the former, the hays from plots (4) and (5) show the more pronounced increase, the difference in the

[7] See " Influence of Nitrate of Soda on the chemical composition of Pasture cuts of Cocksfoot ". Fagan and Evans, this Journal, Vol. II.

[8] Notes taken at the time of sampling indicate that " flowering was far more advanced on the control plot especially in the case of Molinia and Sedges ".

percentage of ash between plot (1) and the control plot being only slight. This shows that basic slag and kainit, especially the former, had the greatest effect on the ash content, sulphate of ammonia having little influence on this constituent. The enhanced value of the hay is better shown when silica-free ash only is taken into consideration, the silica content of the hay from the control plot being much higher than in the others, due probably to the presence of horsetail on this plot.

As in the case of the manurial experiment described above (p. 139), the most pronounced effect on the chemical composition following the application of fertilisers is seen in the higher mineral content of these hays, the percentage of phosphoric acid, lime and chlorine being increased. Of the mixtures applied, basic slag and sulphate of ammonia appear to have the greatest effect on the phosphoric acid content. The phosphoric acid is lowest in the hay of plot (2), but even this herbage has a phosphoric acid content of approximately one and a half times that of the control plot, although slag was not applied to this plot. The superiority in phosphoric acid of the hay from plot (2) in comparison with the unmanured hay is probably due, as already indicated, to the change in the nature of the vegetation growing on this plot subsequent to the manuring; the amount of sweet vernal grass being considerably increased.

From Table VII it is seen that while all the manurial treatments increased the lime content of the hays, some of the dressings were considerably more effective than others. The relative influence of the different mixtures is clear from the order assigned to the plots in the table. Thus it is seen that the complete dressing of artificials increased the lime content more than the incomplete dressings, while the superiority in lime of the hays that received slag shows this manure to have a greater effect than the others on this constituent. Kainit and sulphate of ammonia gave only a slight increase in the percentage of lime, and this, taken in conjunction with the low lime content of the hay from plot (3), suggests that sulphate of ammonia had a depressing effect on this constituent. The control plot gave the herbage with the lowest ratio of phosphoric acid to lime, this ratio being highest in the hay from plot (3).

The results do not show any difference in the iron content of the hay following the application of the fertilisers. The percentage of chlorine is, however, appreciably increased in all the manured hays and that almost to the same extent; plots (4) and (5) being slightly richer than the others.

Of the manures applied these results indicate that basic slag had the most beneficial effect on the chemical composition of the first hay-crop under the conditions of the experiment. When both yield and chemical composition are taken into consideration plot (5), which received a complete dressing, is outstanding.

A comparison of bog-hay with meadow hay.

A comparison of the chemical composition of bog-hay, both manured and unmanured, with the average composition of ordinary meadow hay is given in Table VIII below :—

TABLE VIII.

Type of Hay.	*Crude Protein.*	*Ash.*	*Phosphoric Acid* (P_2O_5).	*Lime* (CaO).	*Oxides of Iron* (Fe_2O_3)	*Chlorine* (Cl).	*Ratio of* P_2O_5 : CaO.
Bog-hay (unmanured)	10.02	2.87	0.260	0.480	0.025	0.35	1 : 1.84
Bog-hay (subsequent to application of slag)	11.50	5.29	0.579	0.958	0.021	1.067	1 : 1.65
Ordinary Meadow Hay	10.31	7.34	0.46	1.66	0.046	0.641	1 : 3.66

These results indicate that, although some types of bog-hay are low in nitrogen, the protein content on the whole compares favourably with that of meadow hay. A distinct difference, however, is shown in the percentage of ash, in which constituent bog-hay is very poor, meadow hay containing approximately twice as much. Even bog-hay to which basic slag has been applied, though superior to the unmanured hay, is still lower in ash content than meadow hay.

All the mineral constituents estimated are lower in bog-hay than in meadow hay. The application of basic slag, however, has increased the phosphoric acid content so that the manured hay is comparable in this constituent to meadow hay. Although the lime content of bog-hay is higher than that of the phosphoric acid, the relative deficiency compared with meadow hay is more pronounced in the case of the former constituent, even the manured hay only containing about half the amount of lime present in meadow hay. The ratio of phosphoric acid to lime is considerably higher in bog-hay than in meadow hay.

The iron and chlorine content of unmanured bog-hay is also lower than that of meadow hay, but the results show that basic slag increases the chlorine content considerably. When, however, the percentage of chlorine in meadow hay is compared with the amount found in some of the samples shown in Table A and B (appendix) the superiority of the former is quite pronounced.

A comparison of the chemical composition of bog-hay with meadow hay shows the chief deficiency of the former to be in ash, phosphoric acid, lime and possibly chlorine.

The feeding value of bog-hay.

Enquiry among farmers who are mainly dependent on bog-hay for their winter fodder has shown that the feeding value of bog-hay is generally regarded by them as being fairly high, and that if harvested under such conditions as those already indicated, the hay has excellent " palatability " and is greatly relished by stock, being often preferred to seed and meadow hay. It must be borne in mind, however, that the type of animal found in these districts is the old-fashioned Welsh Black, which is small in size, slow in maturing, very hardy and able to thrive under poor conditions. Under the Live Stock Improvement scheme we now find Shorthorn and the bigger type of Welsh Black cattle being gradually introduced into the lowland districts, and with these it is found necessary to supplement bog-hay to a considerable extent with concentrates, as alone it is not sufficient to maintain these animals.

As bog-hay has a binding effect it is rarely fed to animals younger than twelve to fifteen months old as they do not thrive, and if possible it is not fed to horses. When fed to dairy cows care is generally taken that it is accompanied with laxative foodstuffs such as swedes and turnips so as to counteract its binding effect. On many of these upland farms, however, swedes and turnips are not grown, the only arable crop being oats, and that often of poor quality. Under such circumstances bog-hay is fed to all classes of stock, even calves, but supplemented in the case of the latter with milk, oilcakes and other suitable feeding stuffs.

The stock for which bog-hay is found most suitable is the store cattle, and these, being small, can be got into a half-fat condition by feeding on this hay alone, only a normal supply of hay being fed. The store cattle, although they put on flesh, do not seem to grow and are easily distinguished by their stunted appearance.

The chief drawbacks of bog-hay, therefore appear to be its binding effect and lack of growth-promoting constituents. When fed alone, with no variation—as is the case on some of these upland farms—it is of the highest importance that these deficiencies should be adjusted.[9] The function of mineral con-

[9] " Some practical aspects of the Mineral Requirements of Farm Animals ". Crichton, *Scot. J. Agric.*, Vol. VII, p. 39, 1924.

stituents in bone-formation and growth has of late received considerable attention, while their importance for the formation of tissues and the digestive juices of the animal is also fully recognised.

From the point of view of feeding the question, therefore, is "what means can be adopted to adjust the deficiency in minerals of bog-hay?" As already shown, the application of fertilisers, especially phosphatic manures, greatly improves the mineral content of the hay. An obvious solution of the problem is to grow crops which are rich in ash, phosphoric acid and lime, which can be fed with bog-hay. The analysis of forage crops, such as the different varieties of kale—carried out in this laboratory—shows these to be very rich in the above constituents and could be profitably utilised for adjusting the ration. Cereal grain, again, are very rich in phosphoric acid, and the feeding of these would minimise the risk of deficiency in mineral matter. In this connection it is of interest to note that "concentrates" which are generally used for supplementing and correcting deficiencies in rations are rich in phosphoric acid but deficient in lime, so that the use of these with bog-hay would result in a diet with excess of phosphoric acid to lime.[10]

A distinction, however, must be drawn between lowland farms—only partly dependent upon bog-hay—which have a certain acreage of arable land, and upland farms, wholly dependent on this type of herbage, but with little, if any, land that can be termed "arable." On the latter, the growing of forage crops is impracticable, and other means must be adopted to correct the ration.

In this connection work carried out by the Department of Agriculture, Union of South Africa, is suggestive.[11] Indoor feeding experiments were carried out with teff hay, and although the chemical composition of bog-hay is superior to the former, the beneficial results obtained on the addition of bone-meal to the ration, as shown by the more rapid growth of young stock, superior fattening of adult cattle and higher milk yields of dairy cows, suggest the suitability of bone-meal for correcting the deficiencies of bog-hay. This conclusion is further supported by other authorities.[12]

To determine the nutritive value of any foodstuff it is essential to obtain information as to its digestibility, and, as far

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[10] Ingle, *J. A. Science*, 1912.

[11] "Phosphorus in the Live Stock Industry". *Journal Department of Agriculture, Union of South Africa*, May, 1924.

[12] Dr. Orr. Address to Section M, British Association, 1925 (other reference given in the address).

as can be ascertained, no information is available on this point in connection with bog-hay. Digestibility trials carried out with sheep on molinia hay,[13] however, suggest that this type of hay is comparable in digestibility to meadow hay, but as the number of sheep were small (3) too much significance cannot be attached to these results.

Briefly summarised, the results of this investigation are as follows.

1. The botanical composition of the samples analysed shows a wide variation in the type of herbage forming so-called bog-hay, some being composed of one or two varieties, while others are composed of several types of vegetation.
2. The chemical composition of these hays shows some types to be superior to others.
3. Bog-hay cut early is superior in composition to that cut later, especially in mineral content.
4. The application of basic slag to bog-areas encourages the growth of a better type of herbage, wild white clover appearing to a small extent.
5. The influence of phosphatic manures appears to be more pronounced on the mineral content of the hays than on the other constituents.
6. Gafsa mineral phosphates is, on the whole, as suitable as the more soluble basic slags for bog-areas and has a more lasting effect.
7. The importance of good drainage on the effect of artificial manures is demonstrated by upper and lower series of plots, Tables C and D.
8. A complete dressing of fertilisers gave a higher yield of hay from a bog-area than an incomplete dressing, the herbage being also superior in chemical composition.
9. Sulphate of ammonia and kainit had less effect both on the yield and chemical composition of the natural herbage of peaty soil than basic slag.
10. Unmanured bog-hay is deficient in ash, phosphoric acid, lime and chlorine. The percentage of these constituents is considerably increased by artificial manures, especially basic slag.

Acknowledgments.

In conclusion, I beg to acknowledge my indebtedness to Mr. T. W. Fagan, M.A., F.I.C., in whose laboratory, and under

[13] "Digestibility of Molinia hay". F. Honcamp and O. Nolte *Expt. Station Record*, Vol. 45, 1921, p. 168.

whose supervision, this work was carried out; also to Mr. William Davies, M.Sc., of the Welsh Plant Breeding Station, for his valuable help in giving the approximate botanical composition of the bog-hay samples.

SEEDS MIXTURE STUDIES: SOME CARMARTHENSHIRE RESULTS.

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The effect of any one component of a seeds mixture on any of the other components has an important bearing on grassland research, and a number of experiments have been designed in conjunction with the Welsh Plant Breeding Station with a view to examining the main factors at work. In this connection the present paper deals in a general way with the results of an experiment conducted at two centres in Carmarthenshire.[1] Seven similar mixtures were put out at each centre in seven half-acre plots, the seeds at Centre 1 being sown in June, 1923, and those at Centre 2 in June, 1924. The seeds were in each case sown with a cereal nurse crop and were given similar subsequent treatments, except that the grazing may have been heavier at Centre 1 than at Centre 2. After cutting the corn, no grazing took place at either centre until after the first hay crop, when the aftermaths were grazed by mixed stock, mainly cattle and sheep. In subsequent years the fields were "put up" for hay in early April.

TABLE I.

The seven mixtures sown at each centre were as follows in lb. per acre:

	1	2	3	4	5	6	7
Perennial rye-grass ...	12	3	—	6	9	9	—
Italian rye-grass ...	—	9	12	6	3	3	—
Cocksfoot ...	6	6	6	6	—	6	6
Timothy ...	4	4	4	4	[illegible]	4	4
Meadow fescue ...	—	—	—	—	[illegible]	[illegible]	[illegible]
Crested dogstail ...	1½	1½	1½	1½	[illegible]	[illegible]	[illegible]
Rough stalked meadow grass ...	1½	1½	1½	1½	[illegible]	[illegible]	[illegible]
English late-flowering red clover ...	4	4	4	4	4	[illegible]	[illegible]
Wild white clover ...	½	½	½	½	½	½	½

[1] Centre 1: Stangrach, Llanfynydd, Carmarthenshire, 500 feet elevation; sown June, 1923. Centre 2: Pibwrlwyd Institute, Near Carmarthen. 100 feet elevation; sown June, 1924.

Botanical analysis of all plots at each centre was made in June, 1926, the average percentage frequency results being given in Table II. The method of analysis may be termed "the percentage estimation method." A total of 10 marks is allotted to each mesh reading, each species being given a mark 0-10, based on the estimated number of tillers occurring within the mesh, 10 readings being taken on each plot.[2]

The plots were kept under periodical observation from their initiation.

TABLE II.

Comparison of swards (percentage estimation) seven mixtures.[3]

	1	2	3	4	5	6	7
Perennial rye-grass ...	45.3	26.7	—	31.2	39.4	33.3	—
Italian rye-grass ...	—	2.8	5.1	1.2	trace	0.2	—
Cocksfoot ...	2.3	4.7	3.7	4.1	—	4.5	4.9
Timothy ...	1.0	3.4	2.8	2.1	—	2.4	6.9
Meadow fescue ...	—	—	—	—	1.3	-	9.3
Crested dogstail ...	9.9	11.0	12.0	14.0	10.3	8.3	10.4
Rough stalked meadow grass	9.5	16.1	10.9	11.3	11.4	14.5	14.2
Late-flowering red clover ...	10.5	12.6	16.4	11.4	11.2	10.6	18.5
Wild white clover ...	8.6	10.5	15.5	11.6	15.6	15.4	18.5
Unsown species (= weeds) ...	12.9	12.2	33.6	13.1	10.8	10.5	17.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Discussion of Results.

The most striking result brought out by the analysis of the herbage is that of the marked effect of the rye-grasses on the stand of meadow fescue. The suppression of meadow fescue when sown together with rye-grasses in seeds mixtures has already been observed in the course of the work at the Welsh Plant Breeding Station.[4]

A direct comparison can be drawn between plots 5 and 7 of the present experiment, both plots having received equal seedings of meadow fescue, rye-grasses being included in plot 5, but replaced in plot 7 by cocksfoot and timothy. The herbage of plot 7 contains 9.3 per cent. of meadow fescue, whereas that of plot 5 has only 1.3 per cent. The results at each centre closely agree in the amount of meadow fescue as shown by the following approximate figures :—

Cent is col basic - plot 5 had 1 per cent. and plot 7 had 8 per cent.
" — " 5 " 2 " " " " 7 " 11 " "

[2] Davies, William : Grassland problems. Some observations on experimental technique and methods of crop sampling. Unpublished.

[3] Average results of two centres.

[4] Critical researches bearing on this problem are being conducted and will be reported upon in due course.

The suppression as shown by these results is directly due to the inclusion of rye-grass in the seeds mixture. From other data collected at Aberystwyth it would seem that the main suppression of meadow fescue occurs during its early growth stages; this grass seems to germinate slowly and to remain in the critical seedling stage for a relatively long period. If sown with other species, *e.g.*, rye-grass, which germinate rapidly and quickly pass the seedling stage, there is set up an inter-specific competition which may cause a still further prolongation of the seedling stage of meadow fescue, and the chances are that many of these seedlings will be unable to survive the adverse conditions and will be killed.

On the other hand, such grasses as timothy and cocksfoot which do not pass out of the seedling stage rapidly, but which, however, make vigorous growth as hay in the first harvest year, do not to any marked extent suppress meadow fescue, thus showing that seedling competition may be of greater importance than that set up during the growth as hay. In this connection it is important to note that the plots under review were not grazed in the seeding year, consequently there was set up a maximum competitive interaction between species, Italian rye-grass no doubt being the greatest aggressor.

The rye-grasses also had a very marked effect on the stand of clovers, the total clover being in direct ratio to the amount of rye-grass sown. In plot 3, where the sward was thinnest, owing to the dying off of Italian rye-grass, there is, however, an increase in percentage clover, due not to a greater number of clover plants but to a slightly higher ratio of clover to total plants.

Periodical observations and notes made on the plots are wholly in accord with the results obtained on analysis and show conclusively the superiority of the clover stand on plot 7, where rye-grasses were omitted from the seeds mixture.

Another point emerging from the data is that where an excessive quantity of Italian rye-grass is sown (plot 8) the second and subsequent years' herbage contains a greater proportion of weeds than where less of this grass is sown, or where it is omitted. Not only does Italian rye-grass act as an aggressor towards other constituents of the mixture but it causes, as a result of suppression in the first year coupled with its biennial nature, an increase in the weed contribution of the subsequent years. It is true, however, that when Italian rye-grass is sown in moderate amounts it assists in weed suppression without undue suppression of the other sown species; this is indicated by a comparison of

plots 5 and 6, which are the least weedy. It is clear, therefore, that a middle course should be adopted, whereby the moderate seeding of Italian rye-grass may act as a check on weeds, assist in production of autumn and winter food supply, as it undoubtedly does,[5] and at the same time not seriously hinder either the growth or the " take " of other constituents of the sown mixture.

Perennial rye-grass as a hay plant must with Italian rye-grass also be regarded as an aggressor species, but with the important difference of being able to keep out weeds for a longer period in the life of the ley, due to its greater longevity. The "non-aggressor" species such as timothy, cocksfoot and meadow fescue are not able to keep weeds in check as successfully as does perennial rye-grass; this is evidenced by the data for plots 1 and 7 (Table II).

It is emphasised that the plots under review have been kept under hay conditions each year; had they been grazed continually, or even had they been grazed during the seeding year, as maiden seeds often are, the percentage composition might have been altogether different, to such an extent is the composition of leys dependent upon management, especially upon time and intensity of grazing.[6]

Summary.

1. The data have served to show that inclusion of meadow fescue, even in fairly large amounts, in seeds mixtures which contain a large proportion of rye-grass, is not to be recommended. Hence, it seems futile to include small seedings of meadow fescue in complex mixtures containing much rye-grass, as is so often done in farm practice. Rye-grass sown in mixtures with red and white clovers may materially lower the stand of the latter.

2. This would seem to be one very forcible argument against the use of complex (= many species) mixtures, where in general the species which are slow in the early growth stages are included in only small quantities, together with relatively heavy seedings of the quicker-growing grasses and clovers. Such slower-growing species may include tall and meadow fescue, meadow foxtail, golden oat grass and smooth stalked meadow grass.

3. Where large sowings of Italian rye-grass are used the herbage after the first two years consists of a much larger percentage of unsown species than where Italian rye-grass is either

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[5] Williams, R. D., Winter Keep. This Journal, Vol. I, p. 119, 1925

[6] Stapledon, R. G., and Davies, William. The effect of the date of " putting up " to hay on the several species contributing to the sward of a temporary ley. This Journal, Vol. II, p. 116, 1926.

sown in small amounts or altogether omitted. Mixtures containing a large proportion of this grass and intended for a ley of upwards of two years cannot be regarded as well balanced.

4. Perennial rye-grass is also an "aggressor" species tending to suppress the other constituents of the mixture, but owing to its greater longevity it is able to suppress weeds for a much longer period in the life of the ley than does Italian rye-grass.

A SHELL MARL DEPOSIT IN MONTGOMERYSHIRE.

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About twenty years ago, when some sheep were buried on land belonging to the Penybryn Farm in the parish of Castell Caereinion, Montgomeryshire, the existence of what is locally known as a "Cragen" bed (Shell Marl) became known.

In the winter of 1925 a sample of the material was brought to the notice of Mr. J. L. John, the County Agricultural Organiser, by a member of one of his classes. The bed being, so far as is known, the first of its kind found in the province of the University College of Wales, its occurrence was considered worthy of record. When the district was visited it was found that immediately to the south-east of Castell Caereinion, at an elevation of 600 feet above sea level, there is an area of lacustrine alluvium, occupying a hollow which runs from south-west to north-east. The alluvial tract is about 1,150 yards long and from 230 to 350 yards wide. At the south-western end there can be little doubt that the alluvium rests on glacial deposits, which indicates quite clearly its post-glacial age. The glacial and fluvio-glacial deposits occupy considerable areas of the surrounding country, particularly in the broad valley in which the village of Castell Caereinion is situated. They may be examined in detail, for instance, in the cuttings on the Welshpool to Llanfair Caereinion Railway near Castell Caereinion Station. At the north-eastern end it appears probable that the lacustrine alluvium rests directly on solid rocks which consist of Salopian shales and mudstones.

The alluvial deposits represent, therefore, an old lake which was in existence in immediately post-glacial times and which has subsequently been silted up.

At various points holes were dug into the alluvium. A generalised section through the deposits with their range of depths being as follows :—

Soil from 9in. to 18in. deep.
Grey blue clay from 6in. to 18in. deep.
Peat from 1in. to 2in. deep.
" Cragen " from 14in. to 24in. deep.
Grey blue clay about 16in. deep.

Some difficulty was experienced in ascertaining with any degree of accuracy the depth to which the lower layer of clay persists owing to the fact that at about five feet below the surface the holes rapidly filled with water.

Each of the above layers contained a quantity of vegetable remains in the form of decayed roots, mainly those of ferns—for example, Pteris—and from the upper layer of clay a large number of seeds were obtained belonging to a common species of Potamogeton (pond weed).

A sharp line of demarcation generally separates one layer from the other, though in some holes a thin layer of impure " Cragen " grading into clay was found resting on the lower clay. In those holes where the " Cragen " did not appear a dark loamy sand occurs below the upper clay; the soil in these places was found to be deeper and the clay over a yard in depth.

A series of samples of the clay lying above and below the " Cragen," as well as of the " Cragen " itself, were taken for examination. Both clays were a mottled greyish blue in colour and on mechanical analysis were found to resemble each other closely in composition. The predominating fractions in each were silt and fine silt, which made up 68% of the whole, the highest percentage of clay found being 14.5.

The " Cragen " in situ is in a pasty condition, due to the water it contains, but on drying it falls into a creamy-white friable powder.

Shells, as its Welsh name implies, forms a considerable portion of the mass of the " Cragen," some being in a good state of preservation, and though extremely fragile are easily washed free from the surrounding material. The shells are fresh water gastropods and lamellibranchs; the number of the different species is somewhat restricted, three only having so far been discovered.

The following table gives the chemical composition of a series of samples of the " Cragen " taken along the length of the area from south-west to north-east, the analysis being based on the dry matter.

TABLE

Lime (CaO)	45·99	43·40	35·52	34·12	23·80
Magnesia (MgO)	1·50	1·21	1·80	0·86	0·38
Oxide of Iron (Fe_2O_3) and Alumina (Al_2O_3) ...	1·60	1·60	4·17	5·48	6·30
Carbonic Acid (CO_2)	30·80		27·10	24·60	15·80
Phosphoric Acid (P_2O_5) ...	0·176	0·162	0·152	0·186	0·159
Sand and Siliceous matter ...	12·30	16·06	27·15	28·42	47·62

It will be observed from the above table that the percentage of lime diminishes as the " Cragen " bed is traced from S.W. to N.E., and that at the same time the amount of sand and siliceous matter increases. The whole suggests that as we proceed from the S.W. to the N.E. of the area we are passing from the deeper part of the lake to the more shallow.

The soil, when its method of formation is remembered, is of the nature that would be expected, being rich in organic matter and shading in places into pure peat. The greater part of the land over the area is down to grass, though a portion near the centre is under the plough. This portion is particularly rich in organic matter, and the prevalent weeds, of which spurrey appears to be the chief, were of the type generally associated with a soil deficient in lime.

The bed is not considered to be of any great importance from an agricultural point of view, for in spite of its high content of calcium carbonate it does not appear by natural means to have any beneficial effect upon the workable portion of the land above it. Its incorporation with the surface soil, which would undoubtedly result in enhanced fertility, is unfortunately not a practicable proposition. Owing to the thin layer in which the " Cragen " is distributed the labour required in excavating it would be far too great. Its interest rather lies in the possibility that there may be other more extensive deposits of a similar nature in the College area. If this is the case, then it may develop into a matter of some importance in connection with the study of the soils in the province of the College. The writer for this reason would be obliged to any reader who happens to know of a deposit similar to that described in this article, or of a neighbourhood where there is any likelihood of its occurring.

The writer wishes to express his thanks to Professor W. J. Pugh, of the Geological Department, for his advice on matters relating to the geology of the formation, to Mr. J. L. John, the County Agricultural Organiser, for drawing his attention to it, and to Mr. Colley, of Penybryn Farm, for facilities to sample the bed.

PRELIMINARY SOIL SURVEY OF THE CREUDDYN PENINSULA.

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Geology and climate are the principal factors which govern the general characteristics of the soil of any district. Soils which have only recently been formed by mechanical disintegration usually take on the properties of the parent rock material, and can conveniently be classified on this basis. Mature soils, on the other hand, show a closer relation to the past and present climatic conditions than to the raw materials from which they were originally produced. Their fertility varies more with the numerous factors which have operated in their origin, depending mostly on physical features and climate. The small area under review differs from the remainder of the county in the greater diversity of its geological formations, and its somewhat less extreme climate. In this case classification into soil types is found to be closely related to the physical features and geology of the district.

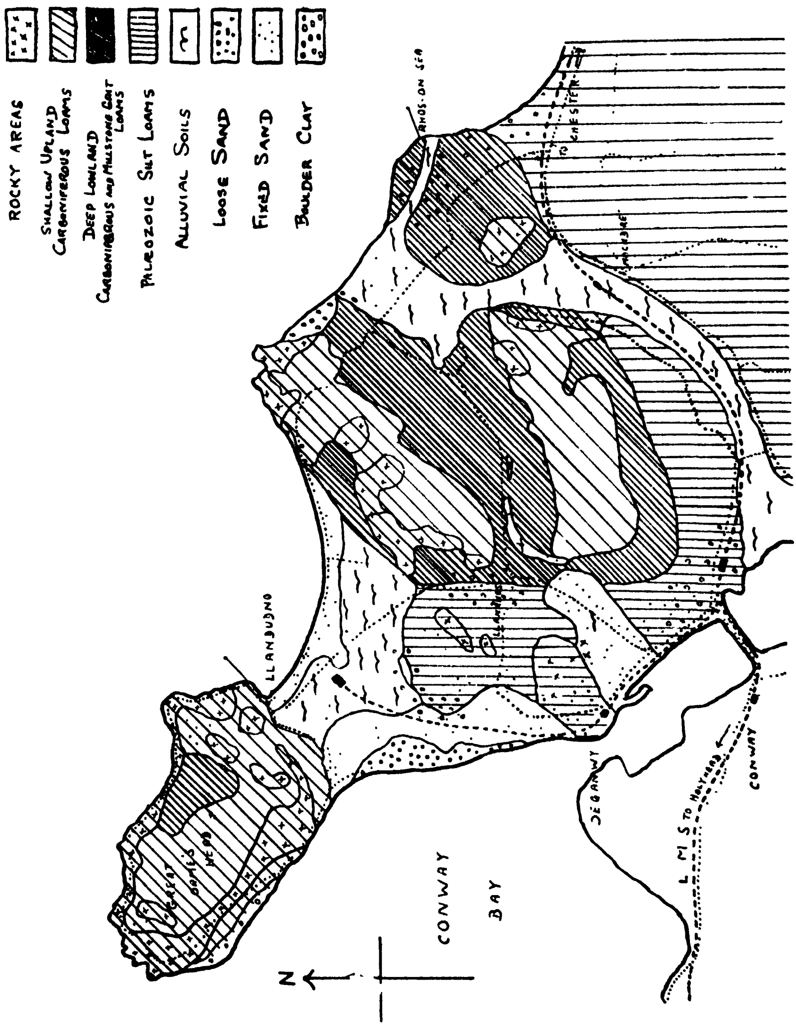
Physical Features.

The Creuddyn peninsula is that portion of Caernarvonshire which is situated to the east of the Conway river. It constitutes about twelve square miles of fairly hilly land, three-fourths surrounded by water and bounded on the S.E. by the hills of Denbighshire. The dominant features are the Great and Little Ormes Heads, of Carboniferous Limestone, and the series of intrusive hills in the S.W., the latter marking the termination of the lava flow from the Penmaenbach mountain across the river. Skirting these hills there are varying depths of hill-wash soils formed by local weathering and transport. There are extensive areas of blown sand, and some alluvial stretches only a few feet above sea-level. The remains of extensive boulder clay formations occur as cliffs along the coast.

Geology.

Compared with adjacent districts this peninsula abounds in different geological formations. The latter can conveniently be studied from Llanrhos, a point a little to the west of the centre of the peninsula. About two miles to the north-west we have Great Orme's Head (679 feet), a mass of carboniferous limestone of about two square miles in area. To the north-east there

extends out another similar formation terminating in the limestone quarries of the Little Orme. To the east there is another larger limestone ridge of about three miles by one mile extending to Rhos-on-Sea. Between the latter ridges there is an extending belt of lower-lying millstone grit, its eastern border being covered



by sandy and alluvial flats. To the south and west the rock is similar to that of the mainland, being Wenlock Shale and Lower Silurian formations. Within the latter, extending for one and a half miles to the north of Deganwy, there are a series of intrusive rocks, Bodlondeb Ash and Upper Brecciated Rhyolites,

forming the Deganwy and Bryniau hills. These upright rocky masses demonstrate clearly how the harder rocks have shown greater resistance to the weathering agencies, for the surrounding softer shale rock has been worn down almost to the present level of the lowlands. Along the south-east border adjoining the mainland we find a belt of Wenlock Shale, extending into the Denbighshire hills. Along the edge of this shale we now have an alluvial flat about 300 to 500 yards in width extending for about four miles. There is evidence that this was the former bed of the Conway river, the little stream at present winding through it serving as the county boundary. Along the west coast there is a wide belt of blown sand over-lying shales and boulder clays.

Climate.

The climate is typically maritime, having mild winters and cool summers, the average annual rainfall being about thirty inches. The district is fortunate in having very complete meteorological records for the past forty-five years. The most striking feature is the low rainfall as compared with the remainder of the county. The rainfall for any special district depends on altitude and relative position. In this particular case the mountains of Ireland and North Wales intercept the prevailing moisture-laden winds from the west and south-west, causing much precipitation, hence tending to produce a drier and warmer climate in this region. The average annual rainfall over a period of thirty years is 29.74 inches, this being from a half to a third

TABLE SHOWING METEOROLOGICAL DATA FOR LLANDUDNO.

	Period	*Jan.*	*Feb*	*Mar.*	*Apr*	*May.*	*June*	*July*	*Aug*	*Sept.*	*Oct.*	*Nov.*	*Dec*	*Year.*
Average Rainfall—inches	1881—1910	2.60	2.07	2.12	1.85	1.92	1.95	2.30	3.02	2.21	3.79	3.07	2.84	29.74
Average Relative Humidity—% ..	do.	83.0	82.0	79.0	75.0	73.0	74.0	76.0	77.0	78.0	80.0	82.0	83.0	78.5%
Average Monthly Temp.—°F	do.	41.3	41.4	42.7	46.5	51.6	57.2	60.0	59.7	56.9	50.9	46.2	42.6	49.8°F
Average Daily Range of Temp. °F	do.	8.3	8.9	10.1	11.5	12.1	12.3	11.7	11.2	11.0	9.5	8.8	8.2	10.3°F
Extreme Maximum Temp., °F	1881—1911	57.8	65.0	68	78.9	81.5	82.0	84.8	90.0	87.0	76.2	64.0	62.2	90°F
Extreme Minimum Temp., °F	do.	14.5	17.5	22.5	27.2	32.4	40.4	42.0	43.4	38.5	29.0	27.2	20.0	14.5°F
Average Monthly Sunshine—Hours	1896—19.0	56.5	73.4	126.9	170	218.9	211.6	204.5	184	147.2	99	64.4	43.9	1601.1

of that of the greater portion of the mountainous regions of North Wales. The average annual temperature is 49.8°F, ranging from 41.8°F for January to 60°F for July, the mean annual range being comparatively small. The average daily range of temperature varies from 8.2°F for December to 12.8°F

for June, giving a fairly steady average daily variation of 10.8°F throughout the year. The lowest recorded minimum temperature is 14.5°F for January, the highest recorded maximum being 90°F for August. The sunshine figures show a continuous rise from 48.9 hours in December to 218.9 hours in May. They remain about the same for June and July, finally falling off again. The climate may be summarised as maritime and fairly humid.

Agriculture.

Economically this district is essentially a coastal pleasure resort and residential area, the chief centre being Llandudno. This resort is being rapidly developed, the residential population having risen to about 20,000, which figure is increased four-fold during the summer months. This good market has given rise to some local market gardening on the lighter soils, but production is far below the requirements of the district, and it is probable that this branch of agriculture could be profitably developed within the peninsula. The larger farms are devoted to dairying, depending largely on the importation of feeding-stuffs rather than their production on the farm. The greater portion of the milk supply, even in the winter, comes by rail from Cheshire and the Vale of Clwyd. There are about 3,000 acres of upland heaths and low-lying sandy areas devoted to mutton production. Most of the better land is under permanent pasture with a comparatively large proportion of hay meadows. The usual rotation, though practised on a very small scale, is oats, roots, oats, followed by seeding down to grass. Most farms produce a fair amount of potatoes and some roots, for which there is a good market. About 400 acres are devoted to estate woodlands, whereas very much more of the more fertile land has been taken up for building purposes.

General.

An ideal soil survey for universal use would consider climate and economic factors as well as the usual main soil characteristics. They all play a part in building up what may be termed " fertility " in its broadest sense. It is found convenient and practicable to classify soils into main types according to their texture, as checked by mechanical analysis, the textural types being further qualified by noting physical features, nature of origin, condition of soil, etc. This textural delineation seems to be the only one that lends itself to approximate field determinations of any soil constants. The placing of boundaries between neighbouring soil types adds greatly to the practical value of any system of soil survey. In

this preliminary work the writer has accurately mapped out the different soil types only in places where the boundaries are fairly definite, as in the case of alluvial flats. Complete accurate delineation would necessitate field to field work over the whole area, as the textural boundaries are not well marked, due to the frequent occurrence of varying amounts of blown sand. Rocky areas, woodlands, and the less productive upland heaths have been mapped out. Altogether forty-six soil samples were taken, each being a composite of about six borings, taken within an area where that particular soil type is well defined. Mechanical analyses of the representative samples were found to agree fairly well in the case of shale soils, alluvium and blown sand, but not in the case of sedentary and transported Carboniferous Limestone soils. The latter vary very much in mechanical composition, mainly according to the nature of the rock surface, slope and the amount of weathering which has taken place. However, these soils are similar in situation and water conditions, and show no great variation in the nature and quality of the vegetation they support. These Carboniferous Limestone soils, together with the associated Millstone Grit soils, form one main type and can conveniently be divided into three sub-types. The following are the principal types of soil distinguished :—

I. Rocky Areas.
II. Carboniferous Limestone and Millstone Grit Loams.
III. Palaeozoic Silt Loams.
IV. Alluvial Soils.
V. Wind Blown Sands.
VI. Boulder Clays.

Typical analyses of soils of each of these types are given in the table at the end.

I. Rocky Areas.

Several large patches of limestone pavements with deep clefts occur, more particularly at the western end of the Great Orme. The exposed surface of the rock along the horizontal plane is bare, except for occasional lichens and mosses, whereas in the shady moist clefts there are numerous flowering plants, shrubs and ferns. The rock comes to the surface at numerous places in all these limestone formations, each area of live rock being surrounded by a belt of broken-off boulders weathering "in situ." Again, the steeper slopes of these limestone hills are made up of the master-joints, extensive tracts of the bare rock being exposed. At the foot of the cliffs there are other wider areas of rocky screes, supporting no useful vegetation. The

intrusive rocks of brecciated rhyolites and ashes forming the Deganwy and Bryniau hills are partly exposed and have given rise to some screes, but these are for the most part covered over by blown sand. The comparatively soft shale rocks of this region are of gentle slope, and show no naturally exposed rock surfaces and resultant screes.

II. Carboniferous Limestone and Millstone Grit Loams.

These soils, most of which occur on the uplands, cover more than half of the surface of the peninsula. They vary in texture from loamy sands to stiff loams, according to the nature of the non-calcareous material present in the limestone and the presence of varying amounts of blown sand. They are reddish or light brown in colour, and invariably well-drained. Except where the soil is shallow they carry good herbage, and in the lowlands are suitable for cultivation. It is noteworthy that, although the annual rainfall is not more than thirty inches, these soils contain very little or no calcium carbonate, whereas the exchangeable calcium oxide [1] is usually under 0.5%, this being due to the leaching of the calcium by percolating waters. The hill-wash soils on the slopes often contain numerous fragments of the parent rock, which on weathering help to replace the calcium which is otherwise leached out of the soil. The Millstone Grit soils are found at a lower elevation between the two limestone areas. It is difficult to distinguish the two kinds, as both give rise to a similarly textured soil. Usually the grit soils are deeper in colour and contain a higher proportion of the " coarse sand " fraction and show a lower " loss on ignition " value. They are fairly well supplied with calcium, probably derived from the adjoining more elevated limestone areas. They are easily worked loams and favourably situated for market gardening. The regions of shallow upland soils of this main type have been delineated. Representative samples taken at various places show the variations in texture that one would expect rather than an average for the whole type. In some parts the soil has been made slightly heavier, due to the presence of the remnants of glacial drift, and in other places made lighter by the addition of some blown sand. A sample of woodland soil bearing no ground vegetation shows much lower values for organic matter and exchangeable bases.

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[1] Exchangeable calcium oxide refers to the easily available portion which can be displaced by treating the soil with neutral salts or dilute acids. Soils with a low content of easily available calcium oxide are generally acid in nature and show a marked response to lime.

III. Palaeozoic Silt Loams.

This type corresponds to the widely spread Palaeozoic Silt Loams of North Wales. On the whole they contain a lower proportion of the coarser particles and organic matter, and somewhat more available calcium oxide. This is probably due to the comparatively less moist climate, and possibly to the accumulation of calcium due to leaching from the neighbouring more elevated limestone formations. This type is fairly uniform in character, usually having about 40% and 20% silt and clay respectively. Examination of the sand fraction in the lighter soils shows the presence of grains of rounded quartz, due to the presence of blown sand. The typical soil type on the lower gentle slopes is a greyish-brown well-drained stiff loam, the greater portion bearing permanent pasture. At the higher levels (from about 800 feet) the soil is a mixture of the sedentary shale and a downwash of the lighter carboniferous limestone soil from above. The small area of igneous rocks near Deganwy gives rise to a type of soil very similar to the surrounding shale rock in mechanical composition, but usually more shallow and less fertile, with considerably less available calcium oxide. To the north-west of these intrusive hills at Maes Du the shale rock is covered by a thick layer of drift soil containing rounded pebbles, this material being again covered by some blown sand, which modifies the soil texture. Beyond the belt of alluvial flat the typical shale soils extend over the Denbighshire hills and beyond into Mid Wales and Shropshire.

IV. Alluvial Soils.

Over 400 acres of fluviatile alluvia, lying at an elevation of only about ten feet O.D., occur in a long strip about a quarter of a mile wide. There is good evidence that this low-lying land, which separates the peninsula from the mainland, was the former bed of the Conway river. The whole area is perfectly level, with fairly abrupt banks on either side. It is a dark grey heavy soil with about 25% clay, 35% silt and 15% organic matter, the subsoil being very similar. Except for the northern portion, where the true alluvium belt widens out into a lighter soil, due to the presence of some blown sand, the plane is subject to water-logging during the winter months. In some parts it is fairly peaty, a representative sample showing 25% organic matter and 0.8% exchangeable calcium oxide. The land is divided up into small fields by open ditches, which drain into a slow stream winding its way through this lowland plane of permanent pasture. An area of a heavy alluvium-like well-drained soil occurs on the level ground between Llandudno and the rising ground to the

south. It seems to be an estuarine alluvium which has now been covered up by blown sand in some portions. Representative samples taken from this typical heavy soil are shown to contain about 25% clay, 35% silt and 15% organic matter. This land is near the town and is mainly used as meadow-land and for the grazing of dairy cows. Towards Craigydon we find a thin horizon of this heavy alluvium overlying a much lighter soil, whereas towards the west shore there is a depth of several feet of this uniform dark-grey soil. There are several smaller patches of peaty alluvium alongside small streams in the centre and south of the peninsula. Such an area near Gloddaeth, formed within the limestone formation, showed 21% clay, 33% organic matter, and as much as 1.7% exchangeable calcium oxide. Another wet peaty area, subjected to blown sand (Tywyn Road), contained 32% coarse sand, 30% organic matter and 1.0% exchangeable calcium oxide. In this work the main alluvial strip has been delineated and the approximate extent of the other regions has been indicated on the accompanying map.

V. Wind Blown Sands.

These are well developed along the west shore, and greatly modify the texture of the soil in certain places up to over a mile from the coast. The gathering ground is that region of the Conway Sands extending to over a thousand acres—lying between the low and high water-mark of the tides. Along the shore there are sand dunes rising to about thirty feet, these containing over 92% coarse sand and a fair amount of calcium carbonate as finely broken up sea-shells. Immediately along the coast there is a band of varying width, up to about 400 yards, of "loose sand" capable of supporting only such plants as can grow on soils with a very poor water supply. A large tract has been artificially fixed in the formation of a golf course. Further inland this formation contains less coarse sand and a correspondingly greater proportion of the finer particles and organic matter, *e.g.*, sand 84%, silt 8%, clay 3%, organic matter 5%. These light soils usually occur on a gentle slope with no available underground water, otherwise they could be developed for market gardening. Where the water-table is near the surface, as in the lowlands adjoining the town, there are several acres of allotments which with good treatment yield average crops. There is an ill-defined transition type of a good loamy soil between the true wind blown sands and the adjoining heavy alluvium further inland. However, most of this more fertile land has been utilised for building purposes.

VI. Boulder Clay.

There is evidence that the whole peninsula has been subjected to the northern glaciation, as drift of this source is strewn along the coast of Caernarvonshire, in some places at altitudes higher than that of the Great Orme. Whatever drift was laid down has since been removed, except for traces occurring as cliffs along the coast, and to a greater extent banked up against the carboniferous formations along parts of the north-east coast of the peninsula. The more inland portions of this drift area have been covered over by local drift and some blown sand. Boulder clay cliffs, showing numerous smooth, well-striated boulders and rising to about thirty feet, occur along the west coast. They seem to be the remnants of a previously extensive area of drift, continuous with other remains of northern drift occurring along the North Caernarvonshire coastline and in the south-eastern portion of Anglesey. Along the low-lying part of the west coast this drift is mostly covered by from one to several feet of blown sand. Elsewhere the glacial drift which is banked up against the Great and Little Ormes has since been covered by much debris of local carboniferous material. Remnants of drift soil are found as surface deposits in various parts of the peninsula. Immediately inland, near Rhos-on-Sea, we find a loamy soil with much gravel and rounded pebbles over-lying the carboniferous rock. Near Maes Du in the west of the peninsula the surface soil is a mixture of boulder clay and local shaly material. Further isolated remains of drift, giving rise to a pebbly, loamy soil, are found in the larger hollow portions occurring on the Great Orme headland.

Conclusions.

The soils occurring in the peninsula have been divided up into eight fairly well-defined types. This does not necessarily imply that each soil type is associated with a definite state of fertility and type of cultivation, but nevertheless some correlation between the soil and the general farming practice is evident. Except in the Pydew district, where there are numerous small-holdings, the well-drained shallow upland soils and the low-lying very sandy soils are given over to sheep grazing, for which they are well adapted. On the less elevated and more level regions of Carboniferous Limestone and Millstone Grit Loams we find the larger dairy farms, the milk being retailed locally at a good price. The usual rotation is oats, roots, barley (or oats), followed by about five years' grass. Some market gardening, and a more arable system of farming, occur on the somewhat lighter soil to

ANALYTICAL DATA FOR TYPICAL SOILS.

	Carboniferous Limestone and Millstone Grit Loams.						Palaeozoic Silt Loams.			Alluvial.			Wind Blown Sands.			Boulder Clay.
	Shallow Upland.		*Deep Lowland.*		*Millstone Grit.*		*Main Type.*		*With Lighter Material.*	*Main Type.*		*Peaty.*	*Fixed Sand.*	*Transition.*	*Loose Sand.*	
	Little Orme.	*Bod-ysgallen.*	*Winfld.*	*Gloddaeth.*	*Coed-y Gell.*	*Winllan.*	*Mochdre*	*Wern.*	*Cwm Howard.*	*Conway Road.*	*Morfa Penrhyn*	*Dolydd.*	*Towyn.*	*Golf Course.*	*Conway Shore.*	*Rhos-on-Sea.*
*Stones Fine Gravel .	16.0	28.0	21.8	4.0	—	5.2	33.3	32.0	5.7	—	—	—	—	1.20	6.8	39.1
Coarse Sand...	9.6	7.1	22.0	13.1	33.7	30.4	10.0	12.9	25.5	8.0	1.9	3.62	76.1	78.5	92.1	13.5
Fine Sand	24.8	15.9	26.3	35.0	18.8	25.7	16.0	16.9	21.7	10.4	19.7	8.0	5.6	12.4	5.4	27.8
Silt...........	15.5	32.5	9.5	11.7	6.5	12.0	18.2	17.7	13.2	21.5	22.0	13.2	3.8	1.0	0.5	14.2
Fine Silt	15.5	19.0	12.7	12.8	13.0	9.2	21.0	19.8	12.0	18.2	15.2	27.5	5.0	1.0	—	19.0
Clay	17.0	14.0	13.8	13.5	15.7	12.3	19.8	20.0	14.5	23.5	24.0	19.0	2.7	.8	—	13.7
Hygroscopic Moisture	1.2	1.6	2.2	2.1	1.8	1.7	1.6	1.82	1.5	2.7	2.1	3.1	0.6	0.6	0.1	1.5
Loss on Ignition	14.1	7.9	12.4	9.8	8.5	6.7	11.4	8.9	9.6	13.0	13.0	24.4	5.2	4.7	1.8	8.1
Exchangeable CaO	0.45	0.16	0.64	0.29	0.46	0.41	0.39	0.42	0.47	0.65	0.35	0.66	0.19	0.21	0.07	0.53

*This fraction is calculated on total dry material.

For economy of space only selected typical analyses are given.

the north of Glan Wydden. It seems that some small-holders are now giving up market gardening in favour of dairying. The main belt of heavy alluvium, part of which is water-logged in winter, together with that portion adjoining Llandudno, are given over to grazing, the portion called Morfa Penrhyn being probably the best grazing land within the area.

Considering the somewhat restricted amount of arable land that is available within the peninsula it is probable that the standard of farming practice compares favourably with that of the surrounding districts. However, one feels that greater advantage should be taken of the very good market within the area. One would expect a greater development along such lines as intensive milk production, market gardening, including glass, and poultry keeping, for all of which there is a suitable soil and climate.

FURTHER NOTES ON WARBLE FLIES IN NORTH WALES.

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Distribution, Abundance, etc.

This paper continues and extends "Notes on Warble Flies in North Wales," which appeared in Vol. I of this Journal. It was there stated that although both *Hypoderma bovis* and *H. lineata* occur in North Wales, the latter is the predominant species, and that the average number of warbles per animal for 767 examined 1920-24 was approximately four per animal. An attempt was also made to correlate the abundance of larvae with the weather of the previous spring, and it was shown that there was a preponderance of larvae situated on the left over those found on the right sides of the cattle examined. Finally the successful use of an ointment composed of one part iodoform and five parts of vaseline (soft paraffin) was described, and it was mentioned that an ointment containing derris was under trial. Further information has since been gained regarding these various parts and is now detailed.

During the period 1920-1926 (inclusive), in which observations have been made, a total of 1,788 cattle of all ages have been examined, yielding 7,008 warble larvae, thus giving a gross average of 4.6. The numbers examined during the years 1920-1923 were low, and it is really only during the period 1924-1926 that considerable figures were collected. During these three

years care has been taken to make the counts during March and April in order to ensure as far as possible that they should be made before the earlier species, *H. lineata*, had commenced to leave the cattle to pupate.

Details as to the situation of the larvae have now been obtained for 1,515 cattle yielding 6,058 larvae; of this total 3,304 occurred on the left and 2,754 on the right sides respectively, giving an excess of 550 on the left.

In the previous article tables were given suggesting correlation between the abundance of warble larvae and the rainfall of the months April-July of the preceding year. These data are set out in Table I, the rainfall figures inserted under each year being those for the period April-July of the year preceding. It will be noted that the low infestations of 1921 and 1925 followed heavy rainfalls. All rainfall data are from Penrhyn Gardens, Bangor.

TABLE I.

Year.	*Cattle.*	*Warbles.*	*Average.*	*Rainfall of previous summer April-July.*
1920	59	194	3·29	7·58
1921	58	103	1·70	21·98
1922	106	615	5·80	7·01
1923	144	1,317	9·14	9·93
1924	401	844	2·10	10·74
1925	357	1,034	1·92	17·30
1926	613	2,764	4·50	10·69

Since the data for 1924-26 include a number of cattle from the districts of Denbigh and Ruthin, rainfall figures for that area have been obtained, and are as follows :- ·1923, 9·21 inches; 1924, 13·94; 1925, 8·04.

During 1925-26 some figures were collected from localities in Flint and Denbigh, as well as in Caernarvon and Eastern Anglesey, whence the bulk are drawn. In each case the data as far as possible are from groups of contiguous farms in order to gain some idea as to the degree of infestation in different localities.

Taking the figures for 1926 (which show a general average of 4.5) we find fifty-eight cattle from an upland district in Denbighshire yielding an average of 11.0 per animal, and thirty-one cattle from the Ogwen Lake district averaging 12.9. In one small herd on a sheep farm in this group three heifers were

without larvae, whilst the next three yielded 21, 65 and 48 respectively. Enquiry revealed that the first three grazed during the previous summer in some exceptionally shady and well-watered fields in the lowlands, whilst the three heavily infested animals remained on the open slopes of the mountain valley. It has been necessary to enquire into the movements of all cattle examined, since young cattle are frequently " summered " in Anglesey, and on the lowlands, before being brought back to their original homes; whilst in lowland dairy herds mountain cattle may be purchased, etc. By these enquiries cattle were sorted into their correct groupings. Forty-six cattle from East Anglesey averaged 7.2. In one lowland herd near Denbigh twenty-one cows averaged 1.16, whilst fourteen young cows (1st calf) averaged 18.8. Subsequently 158 cattle from adjacent herds averaged 1.8 each. It is perhaps significant that these fourteen young cows had grazed together on rough, marshy riverside land during the summer of 1925, whilst the rest of the 179 examined had grazed on excellent land. It is, however, well known that young animals become more heavily infested than older ones; nevertheless the remark made in the previous article that " there appears to be a relatively higher infestation on the rougher lands than in the more highly farmed districts " is borne out.

Control Experiments.

As already stated both species of warble, *Hypoderma lineata* and *H. bovis*, occur in North Wales, the former being the more abundant and appearing earlier in the spring than the latter; otherwise, except for details of habits and structure, they are very similar, and can be similarly treated. One important point arises, however, that where both species are present in a herd (as is not infrequently the case) the period during which warbles are present is much extended, and may last from February to July, entailing a much longer series of control applications than if only one species were present. Two lines of attack suggest themselves: (1) prevention; (2) treatment after appearance. The first would be ideal, but has apparently been less tried than the second, and presents certain formidable difficulties (especially in rough districts where young cattle are grazed over wide areas and seldom handled after turning out in spring), since preventive measures would seem to involve frequent dressings.

Up to the present, then, control experiments in North Wales have been confined to testing two ointments recommended in the United States by Bishopp and others, and used there with considerable success (1, 2 and 8).

These ointments are (1) iodoform, one part; soft paraffin (vaseline), five parts; and (2) derris powder, one part; soft paraffin, two parts. The method of application is to press the ointment into the orifice of the warble, which is used for respiration by the larva, thus killing the latter. Control experiments along these lines were commenced in North Wales in 1923, but owing to pressure of other work at the same period the experiments have been on a relatively small scale, whilst the cold, wet summers prevailing have minimised the numbers of larvae present, without doubt. The results obtained with iodoform ointment during 1923-24 were recorded in the *Welsh Journal of Agriculture*, Vol. I (4). Briefly, 186 cattle (chiefly cows) were treated. Six treatments were made between Feb. 23rd and May 30th (Bishopp recommends four), and the numbers present at successive dressings were 345, 295, 137, 128, 49 and 10 respectively. Most of the ten herds used were infested with both *H. lineata* and *H. bovis*, and the larvae present at the first dressing were chiefly the former, whilst the ten remaining alive at the end were all of the latter species. It was practically impossible to enumerate the total number of larvae present throughout the experiment, as fresh batches of larvae continued to make their appearance through the hide up to the fourth treatment, thus keeping up the numbers present, despite a heavy mortality after each dressing. This ointment is easy of application, and costs about 1/- an ounce, which amount suffices to treat from 70 to 100 warbles. In actual practice four treatments would suffice. After application a considerable number of dead larvae usually project from the orifices, and can be readily removed. The only objection appears to be the characteristic odour, which it was thought by some farmers might affect the milk of dairy cows. Most of the cattle used were dairy cattle in milk, and in no case was any adverse effect noted. In 1924 some preliminary trials were made with the derris ointment, and results from three herds, A, B, C, are given in Table II.

TABLE II.

	Herd.	*A.*	*B.*	*C.*	*Total.*
Number of Cattle	...	38	41	12	91
Number of Warbles at first application	...	6	150	22	178
Ditto. Second application ...	...	19	46	29	84
Ditto. Third application ...	...	7	38	13	58
Ditto. Fourth application ...	...	0	65	4	69
Ditto. Fifth application ...	...	13	2	—	15
Ditto. Sixth application ...	...	2	—	—	2

Note.—The herds utilised contained a considerable number of young cattle, and owing to favourable prices a considerable number were sold, disturbing the experiment seriously.

In 1925 six herds containing 141 cattle were utilised and the results of four treatments given between the end of March and May 30th are shown in Table III.

TABLE III.

	Herd.	*A.*	*B.*	*C.*	*D.*	*E.*	*F.*	*Total.*
Number of cattle ...	...	15	49	40	18	9	10	141
Number of Warbles—								
First application	...	40	22	16	19	29	13	139
Second application	...	18	27	2	14	38	58	157
Third application	...	—	12	1	—	2	15	30
Fourth application	...	—	1	—	—	—	2	3

Note.—Five cattle were removed from herd F before the last count.

In addition Mr. G. E. Shaw, a former student, dressed seventeen cattle on a Cheshire farm; 117 warbles were present at the commencement; three applications were made at fortnightly intervals; and four larvae remained alive at the conclusion.

The killing properties of derris appear to be excellent; the ointment is odourless and the cost is low—about 2½d. per ounce, in experimental amounts. On the other hand, the ointment was found to be much more difficult to apply, and olive oil was utilised, the ointment then consisting of one part powdered derris, one part soft paraffin, and one part olive oil. This improved the texture and rendered application easier. Another important point found was that the larvae did not leave the hide so readily after death, but tended to remain within the hide, together with some pus, healing being delayed. In numerous cases it was very difficult to tell by external appearances whether warbles treated a month previously were dead or not, but on slight pressure being applied, a dead larva, together with some pus, could be extracted. A few even remained six weeks after death. This is a disadvantage. Dr. Stewart MacDougall (5) obtained excellent results with derris as a fluid, 1oz. to a pint of water effecting a control of 94%. The same writer reports good results with nicotine sulphate preparations (6). The Ministry of Agriculture recommend a dressing of tobacco powder and lime (7), and the results of experiments with this preparation in Glamorgan and Monmouth in 1924 are given by Thompson (8), who obtained 90% mortality on tied cattle and 74.5% on loose animals by two dressings only. MacDougall (*op. cit.* 5) also records 82% control with this method.

It is evident that the last word has by no means been said on this line of control, and also that several remedies exist which will kill warble grubs, if applied with reasonable care and

regularity, and that general action in this direction would speedily bring about a marked reduction in numbers.

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EXPERIMENTS ON THE CONTROL OF POTATO LEAF-ROLL.

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A considerable amount of evidence has been accumulated during the last few years to prove that virus diseases are largely responsible for the loss in cropping power of potatoes when grown for several years without change of seed. Except in the best seed producing areas this reduction in cropping power becomes progressively heavier each year that home-saved seed is planted until nearly the whole crop is infected. It follows, therefore, that a check can be put upon this loss by the usual practice of purchasing a quantity of relatively virus-free seed from Scotland each year, or better still, by renewing the entire stock required for planting at least every two years. This method of maintaining the yield, however, is not without its disadvantages; amongst these may be mentioned the high initial cost of the seed and its carriage from Scotland; the frequent difficulty experienced in securing early delivery and the consequent impossibility of " boxing " new Scotch seed; the uncertainty as to the effect upon the tubers of first allowing them to sprout in a clamp before distributing them for seed purposes, for, during grading and transport, many of the first sprouts will be rubbed off. Finally, it should be pointed out that—other things being equal—good seed potatoes can only be produced under conditions which prevent the spread of virus diseases;

such conditions do not obtain in all the seed producing areas, even in Scotland.

Under these circumstances it is in the general interests of agriculture to discover some means by which home-saved seed will retain its productivity as long as possible, and this, to a large extent, is a question of reducing the spread of virus diseases in the crop. Since 1923 the writer has been engaged in exploring various methods of securing this desired control over the spread of virus diseases, and although the work has met with only partial success, it is considered advisable to place the results on record in the form of a progress report. Of the eight or nine supposedly distinct maladies which are grouped together as virus diseases there is little doubt that, in Wales at all events, the most serious in reducing the yield are leaf-roll and the somewhat ill-defined disease known as crinkle. In the present work attention has been directed mainly to the control of leaf-roll, and the results are here summarised under three heads, *i.e.*, (1) The removal or "rogueing" of diseased plants from the crop; (2) The selection of tubers from healthy plants at lifting time on the basis either of the size of tuber or of the vigour of the "parent" plant; (3) The lifting of the crop from healthy plants as early as possible in the growing season.

(1) Rogueing out Diseased Plants.

In 1924 four small plots of each of four varieties were planted from stocks which had been exposed to varying chances of infection from leaf-roll in 1923, the general arrangement of one such plot being as follows :—

1 row New Scotch seed of Kerr's Pink with 0% leaf-roll.
7 rows of Kerr's Pink with 17.9% leaf-roll.
1 row New Scotch seed of Great Scot with 0% leaf-roll.
6 rows of Great Scot with 19.3% leaf-roll.
1 row New Scotch seed of Tinwald Perfection—1 plant leaf-roll.
4 rows of Tinwald Perfection with 8.2 % leaf-roll.
1 row New Scotch seed of Arran Comrade with 0% leaf-roll.
3 rows of Arran Comrade with 32.9% leaf-roll.

The number of tubers planted (excluding the new Scotch seed in each case) and the percentage of leaf-roll in each plot, in 1924, were as follows :—

Kerr's Pink	175*(17·9).	175 (23·0),	100 (27·0),	100 (33·1).
Great Scot	150*(19·3),	150 (10·2),	75 (16·0),	75 (9·5).
Tinwald Perfection ...	100*(8·2),	100 (2·0),	50 (4·0),	50 (4·1).
Arran Comrade	75 (32·9),	75 (24·5),	50 (67·0),	50 (59·8).

* To which must be added a row of twenty-five new Scotch "seed".

The first definite signs of disease appeared on July 8th, and between that date and August 6th every plant was examined at least twice and diseased specimens were removed.

The entire produce of the remaining apparently healthy plants from each plot was lifted in November, boxed separately, and planted in 1925. The most casual inspection of the plots in 1925 was sufficient to show that the rogueing had been quite ineffective, since far more disease was present in all plots than in the previous year. This failure to control the spread of disease was clearly seen in the plants raised from the healthy rows of Scotch seed planted between the infected plots, these giving the following percentages of infected plants : Kerr's Pink 9.1%, Great Scot 17.4%, Tinwald Perfection 6.6%, Arran Comrade 26.6%. Special precautions had been taken to reduce the chances of infection in the row of healthy Scotch Kerr's Pink, for this row adjoined mangolds on one side, whilst on the other side the three adjacent rows of partially infected material not only had diseased plants removed but also their healthy neighbours in the rows.

Although these results do not give much encouragement to the possibility of controlling leaf-roll by rogueing out diseased plants it is necessary to bear in mind both the high initial infection in the experimental plots and the fact that the entire progeny was planted the following year. It is probable that a much less careful rogueing of an ordinary commercial crop, followed by saving seed in the usual way for planting, would show a distinct improvement in the next year's crop; experiments on these lines are in progress.

The problem is somewhat different in upland, wind-swept areas where the normal spread of leaf-roll is not great, and in such areas there can be no doubt that attention given to rogueing would be repaid by the increased productivity of the home-saved seed. Under these conditions stocks have been maintained for five years on the College Farm mountain land with less than 1% of leaf-roll present.

(2) Tuber Selection.

Experiments were laid down in 1924 to determine whether the amount of leaf-roll in a crop was affected by (*a*) the size of tuber planted, and (*b*) the vigour of the " parent " plant.

(i) In one trial the vigour of the " parent " plants was not known, and the stocks had been exposed in 1928 to relatively heavy chances of infection from leaf-roll plots. Ware, seed and chats of several varieties were graded in the usual way over a $1\frac{3}{4}$in. and $1\frac{1}{4}$in. riddle. These were planted in separate rows and

each plant was examined for symptoms of secondary leaf-roll during the season. The following table gives the number of tubers planted and the percentage leaf-roll occurring in each variety and size of tuber used.

TABLE I.

Variety.	*Ware.*	*Seed.*	*Chats.*
Kerr's Pink ...	150 (29·0)	175 (31·0)	175 (31·0)
Great Scot ...	125 (46·0)	125 (45·0)	125 (43·0)
Tinwald Perfection ...	100 (1·0)	100 (3·0)	100 (1·0)
New Century ...	75 (39·0)	100 (26·0)	100 (23·0)

Schultz and Folsom (3) have expressed the opinion that selection of the largest tubers for planting will reduce the amount of leaf-roll and mosaic in the crop. Unfortunately, no support for this view has been found in the writer's trials.

(ii) In the second trial the tubers were selected from plants exposed to relatively little chance of infection in 1923. The " parent " plants had been compared as regards vigour of growth and were lifted separately, so that it was possible to divide the progeny into two lots—those from plants with more than the average yield of the row and those from plants with less than average yield. Thus, plants which gave more than 32oz. for Arran Comrade, 24oz. for Kerr's Pink, 31oz. for Great Scot, and 30oz. for Tinwald Perfection, supplied ware, seed and chats from " best " plants, whilst those plants giving distinctly less than these yields supplied tubers from " worst " plants. If the percentages of leaf-roll present in the plants raised from the ware, seed and chats respectively are examined regardless of the vigour of the " parent " the following results are obtained, the figures referring to ware, seed and chats respectively and to an examination of 200 plants in each case : Arran Comrade 8%, 11% and 5%; Kerr's Pink 4%, 6% and 1%; Great Scot 27%, 26% and 18%; Tinwald Perfection 3%, 1% and 2%. These results show, as in the previous trial, that selection of the largest tubers did not effect any perceptible reduction in the amount of disease present; indeed, a greater reduction occurred where the small tubers were used for planting.

Table 2 shows also that no reliance can be placed upon an attempt to improve the health of the crop by selecting tubers

from the most vigorous plants. In each case the figures represent the percentage leaf-roll present in 100 plants in 1924.

TABLE II.

Variety.	*Best Ware.*	*Worst Ware.*	*Best Seed.*	*Worst Seed.*	*Best Chats.*	*Worst Chats.*
Arran Comrade	12	4	16	6	8	0
Kerr's Pink ...	6	2	6	4	0	5
Great Scot ...	32	22	19	31	18	18
Tinwald Perfection ...	4	2	2	0	4	0

Clearly the results suggest that tubers from the smaller healthy plants are more likely to produce a healthy crop than are tubers from the largest plants. So far as the writer is aware, the only work on the effect of the " parent " plant on the yield obtained from its progeny is that of " W.D.D." reported in the Journal of the Department of Agriculture for Ireland in 1923 (4), this writer expressing the view that some control of virus diseases could be obtained by selecting tubers from the largest and most vigorous plants. The present writer is of the opinion that this may well be true of areas in which little or no transmission of disease is taking place. In localities, however, in which the diseases are spreading more rapidly the larger plants are more likely to act as aphis traps and so to become infected whilst less vigorous neighbouring plants remain healthy.[1]

This suggestion is borne out by another trial in 1923 in which a row of old (1920) seed of Kerr's Pink, showing 29.5% leaf-roll infection, was planted in the virus trials between two healthy, vigorous rows of the same variety. When the progeny of the 1920 seed was planted in 1924 only 28.3% leaf-roll developed. It would certainly appear that no disease transference had taken place either from other rolled plants in adjacent plots or from diseased plants in the row itself. Yet transmission occurred in the surrounding plots, for the progeny of the two healthy rows on either side of the 1920 seed became diseased to the extent of 18% and 26% respectively. This result, in the writer's opinion, was due to the sheltering of the partially diseased old seed by the more vigorously growing neighbours.

[1] N.B.—It is, perhaps, hardly necessary to state that all available evidence tends to show that " green-fly " or aphides are responsible for most of the transmission of virus diseases to healthy plants, although other insects may also be implicated.

(3) Early Lifting.

It is generally accepted that healthy plants become infected only through the foliage,[2] and that since time is required for the disease to travel down the stem to the underground parts, by lifting the crop sufficiently early it should be possible to obtain stocks of healthy seed for planting.

(A) In order to obtain information as to the latest date on which lifting could take place with a reasonable assurance that the seed stocks would be healthy, the following experiment was laid down in 1923. Of three adjacent rows of Arran Comrade (A, B and C) row C, on the windward side, had every plant rolled; the other two rows being quite healthy. On four successive dates (July 28th, August 7th, August 20th and Sept. 14th) a single tuber was detached from ten plants in each of the three rows and stored separately; the rest of the crop from each plant being lifted in early December. There were some losses during storage owing to the depredations of a rat, and only such tubers as had not been displaced or gnawed were planted in 1924. The result of this trial is given in diagramatic form in Text Figure 1, whilst photographs of some of the plants raised from these tubers are reproduced in Plate facing page 176. All tubers obtained from the infected row produced leaf-roll plants in 1924.

A number of interesting conclusions can be drawn from this trial, though they are, of course, only strictly applicable to the variety used, the season, and other conditions under which the experiment was carried out.

(1) There is no evidence of infection prior to July 28th, even in row B, next to rolled plants, for although the absence of disease in the tubers lifted on that date does not necessarily imply that the remaining tubers were healthy, it is unlikely that all the twenty tubers would have proved to be healthy if the plants had become infected much before that date.

(2) The heavy infection of the 104 plants raised from row B (44.2%), as compared with the disease in the 125 plants raised from row A (23.2%), is strong evidence that the disease passed from infectors in row C, and not from other sources. On the aphis theory of transmission it would appear from the occurrence of a plant in row B (B10) and of four plants in row A (Nos. 1, 3, 4, 9), which escaped infection, that aphides tend to stay on a plant unless dislodged by the wind, so that the force and

[2] N.B.—Discussion as to whether infection can also pass through the soil is deferred until the results of experiments, at present being carried out by the writer, become available. In any case, there can be no question that infection through the foliage is by far the most important way in which leaf-roll is transmitted.

direction of the prevailing wind are of considerable importance in any attempt to raise virus-free seed. This has been repeatedly confirmed by the writer during the last five years when examining potato crops in North Wales; home-saved seed has invariably retained its productivity longer on bleak, wind-swept fields than under sheltered conditions. Walton (5) has shown that shelter plays an important part in aphid infestation of potatoes.

(3) It is improbable that the only healthy tubers out of twenty raised from plant A8 would have been lifted in succession up to August 20th if the plant were already infected, yet the virus had penetrated to all the remaining seventeen tubers by early December, whereas in plants A5, A7 and B7 six out of seven, two out of five, and eleven out of twenty-two respectively, escaped infection although the virus had already reached one tuber by August 7th. Unless one is to assume either that the infection of plant A8 was far heavier, or more virulent, than in the case of the other four plants, or alternatively that this plant was infected near ground level, whilst the others harboured aphides only on the top leaves, it would appear that the rate at which the virus passes through the plant varies considerably in different individuals.

(B) Another trial was begun in 1924 with the object of testing the relative value for seed purposes of early lifting as compared with removing the haulms and allowing the tubers to " mature " in the ground before raising. Two plots, each consisting of perfectly healthy seed of two varieties, were planted, in the one case (plot A) between ten yard belts of only slightly infected stocks, and in the other case (plot B) between similar belts of heavily infected material. On July 17th, August 6th, August 19th and September 3rd ten alternate plants in the centre of each plot were lifted from each of the two varieties, the produce from each plant being stored separately. At the same time the intermediate plants had their haulms removed, but the tubers were left in the ground until November 3rd. On this last date, also, ten plants were lifted and stored with a view to showing the amounts of infection present in the mature crop at the normal lifting time. Text Figure 2 helps to make the procedure clear, the squares in the middle of the plot representing the " lifted " plants and the circles the plants which had their tops removed. Since it was possible that infection might not reach the middle of the plots, eight plants along one side as well as all the remaining plants in row 8 were lifted on November 3rd, with the object of determining just how far the disease had spread into the plots. These twenty-two plants are referred to below as " end " plants.

The amount of disease appearing in the crop raised from these plots in the following year is shown in Table 8.

TABLE III.

Date.	Kerr's Pink.				Great Scot.			
	Plot A.		Plot B.		Plot A.		Plot B.	
	Total Tubers.	*% L. Roll.*	*Total Tubers.*	*% L. Roll.*	*Total Tubers.*	*% L. Roll.*	*Total Tubers.*	*% L. Roll.*
July 17th.								
Lifted	135	0	136	0	109	0	108	0
Tops Cut	162	0	134	0	70	0	77	0
Aug. 6th.								
Lifted	143	0	139	0	114	0	102	0
Tops Cut	138	2.1	149	0	91	0	70	1.4
Aug. 19th.								
Lifted	142	0	141	0	119	0	94	0
Tops Cut	91	0	148	5.4	80	0	64	1.5
Sept. 3rd.								
Lifted	130	0	164	4 3	93	0	92	0
Tops Cut	121	1 6	112	0	97	0	113	0
Nov. 3rd.								
Final	114	8.7	188	23.4	102	0	102	0

With the exception of one tuber on each of two plants from which the haulms were removed, no disease occurred in either of the Great Scot plots. The distance to which the disease penetrated the plots is indicated by the state of health of the progeny from the " end " plants when grown in 1925. In plot A all the " end " plants remained healthy, but the following amount of disease occurred in the " end " plants of plot B :— Plant No. 2 (4 tubers), No. 5 (1), No. 6 (2), No. 7 (4), No. 18 (1),[3] No. 21 (1).

In plot A of Kerr's Pink no infection occurred except in the case of tubers left in the ground until November 3rd. Even in plot B, where the chances of infection from neighbouring plants was very great (much more so than in plot B, Great Scot), leaf-roll first made its appearance in the tubers lifted on September 3rd, whereas by November 3rd 23% of the tubers had become infected. Here, also, the haphazard way in which leaf-roll spreads is indicated by the health of the " end " plants; in plot A disease occurred in No. 19 " end " plant (6 tubers), No. 20 (11), No. 21 (4), No. 22 (10); whilst in plot B disease was found in No. 2 (1), No. 3 (1), No. 4 (6), No. 5 (2), No. 18 (3), No. 23 (1).

[3] N.B.—In this plot, in each variety, early lifting was begun at No. 7 plant in the row instead of No. 8, so that No. 18 " end " plant abutted on the plant lifted on September 3rd. There were also twenty-six plants to the row instead of twenty-five, so that the extreme left-hand " end " plant received the Number 23.

EFFECT OF EARLY LIFTING. Row A. Two rows from source of infection.

HEALTHY PLANT RAISED FROM TUBER DETACHED FROM PLANT A8 ON AUG. 20, 1923.

LEAF-ROLL PLANT RAISED FROM TUBER DETACHED FROM PLANT A8 ON SEPT. 14, 1923.

LEAF-ROLL CROP FROM FINAL LIFTING IN DECEMBER OF PLANT A8.

HEALTHY CROP (2 REAR ROWS) FROM FINAL LIFTING IN DECEMBER OF PLANT A1.

It is clear from both the 1923 and 1924 trials that the most certain method of preventing infection of the seed stock is to lift sufficient tubers for that purpose as early as possible in the season, a similar conclusion having been arrived at by Botjes in Holland (1) and Murphy and McKay in Ireland (2). The latest date at which this can be done varies, as the writer's trials show, very considerably in different seasons, but there appears to be little risk of infection in the more open areas of North Wales before the end of July. Under ordinary farm conditions the crop would be exposed to far less risk of infection than was the case in these two trials, and the writer is of the opinion that good seed could be lifted up to the middle of August from slightly infected crops in North Wales, providing that the smaller, healthy plants, as far removed as possible from diseased ones, were selected for the purpose. Finally, it is obvious from Table III that no advantage over the early-lifting method was gained by removing the haulms and leaving the tubers in the ground until late in the season. There was, on the other hand, some risk of infection in such cases from some agency as yet unknown.

The writer wishes to express his indebtedness to Professor R. G. White for help and criticism, and to Messrs. O. R. Morris and D. E. Green, without whose careful assistance in the field it would have been impossible to carry out work of the nature here reported upon.

Summary and Conclusions.

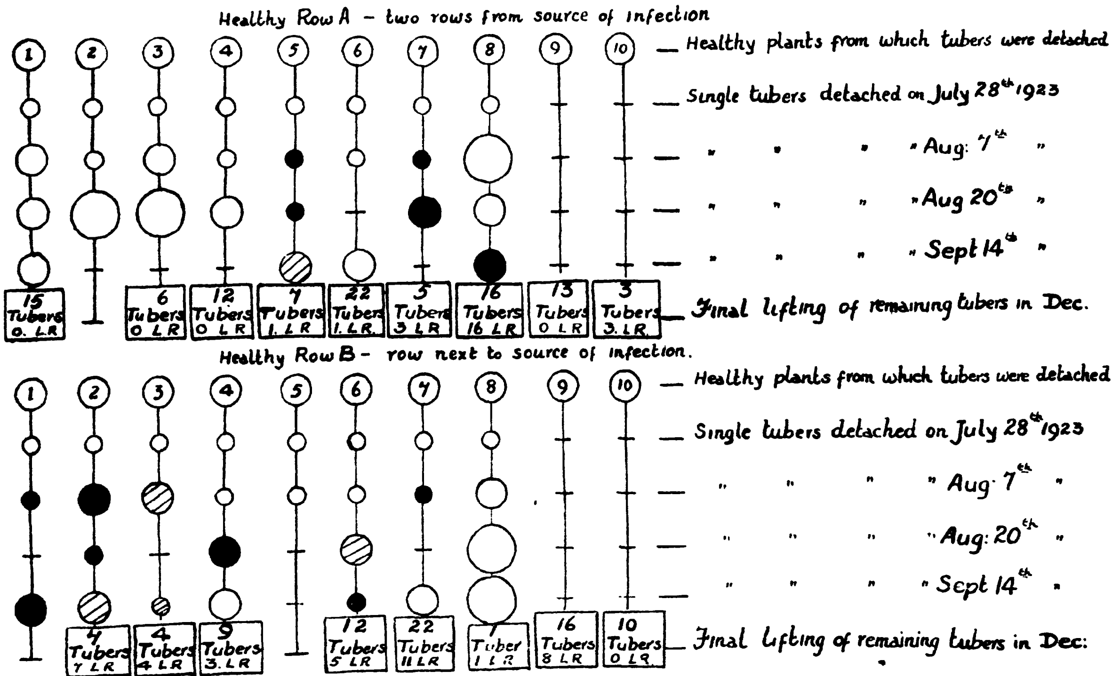
(1) The present account is a progress report on some attempts to control leaf-roll in the field, carried out by the writer since 1923.

(2) Rogueing out diseased plants is only likely to be of value in slightly infected stocks and in areas in which transmission of leaf-roll takes place only slowly.

(3) No evidence could be found for the view, sometimes expressed, that an improvement in the health of the crop could be effected either by selecting large tubers, or those from the most vigorous plants, for seed purposes. There was, on the other hand, some indication that the smaller tubers, selected from the less vigorous healthy plants, produced the healthiest crop in the following year.

(4) Evidence is presented to show that there is little risk of perpetuating the disease if tubers are lifted for seed not later than the middle of August, so long as the crop is only slightly infected and is growing in an exposed field, and that tubers are selected from healthy plants as far removed as possible from diseased ones.

Figure I.

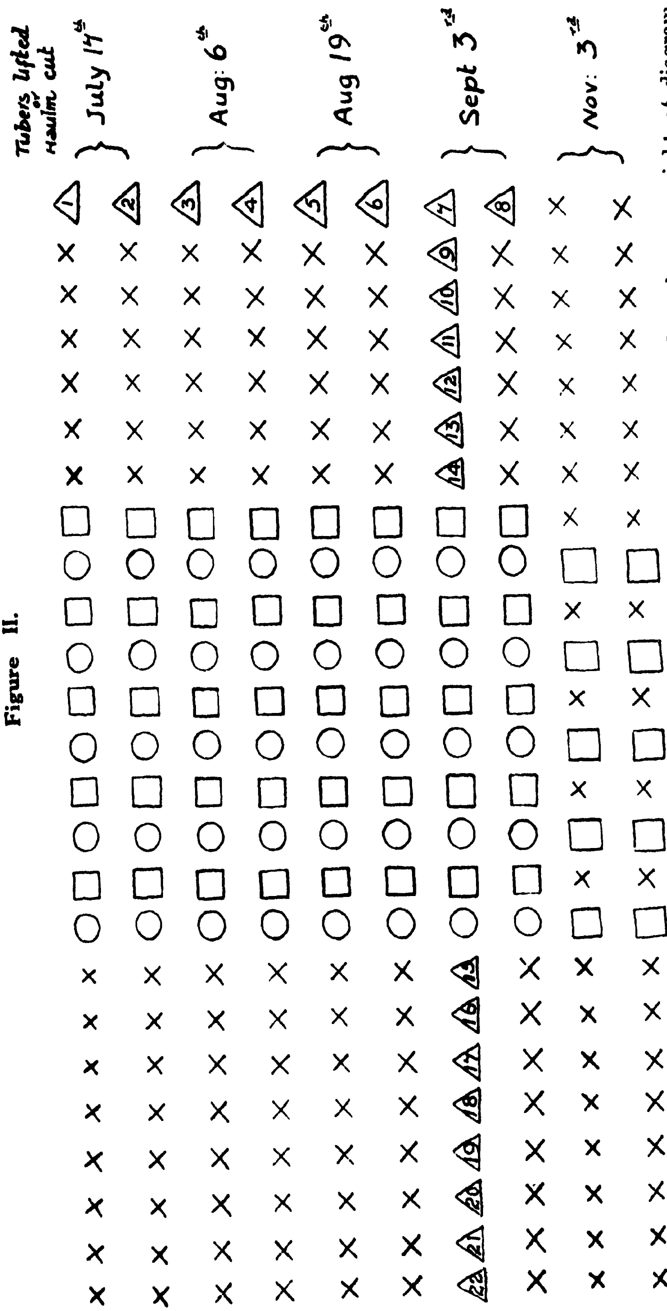


The size of tuber detached (ware, seed or chat) is indicated by the size of circle.

Black circles = Leaf-roll infected tubers. Shaded circles = Planted 1924 but failed to grow.

—— = Not planted in 1924. White circles = Healthy tubers.

Figure II.



A Cross = Plant not included in experiment. A Square = Plant lifted on date shown on right of diagram.
A Circle = Haulm removed on date shown on right of diagram.
A Triangle = "End", plant lifted on November 3rd.

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THE RELATIVE RESISTANCE OF WHEAT VARIETIES TO BUNT *(TILLETIA TRITICI).*

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I. Introduction.

II. Experimental Data and Discussion of Results.

1. Pure line selections of Hen Gymro.
2. Foreign varieties selected for resistance.
3. Common British varieties.

III. Biological Observations.

IV. Summary.

V. References.

I. Introduction.

In 1923 the attention of the present writer was called to the high percentages of bunt (*Tilletia tritici*) occurring in some of the pure line selections of Hen Gymro wheat which were under study by Mr. T. J. Jenkin at the Welsh Plant Breeding Station. The selections were made for the most part in 1920 and multiplied on the ear to row system, and in three years the majority of the lots were found to be badly bunt contaminated.[1] Since Hen Gymro is known to be a composite variety, including a series of types which differ by clearly marked morphological characters

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[1] In subsequent years the disease was satisfactorily controlled by the application of copper carbonate dust (see 16).

(8), an experiment was started with the object of testing a number of pure line selections in the hope that some might be found to differ also in regard to bunt resistance. For comparison with Hen Gymro certain common British wheat varieties were included in the trials, together with several varieties from other countries which have been recorded as possessing exceptional resistance to bunt.

It is not necessary on this occasion to review in detail the work already published on varietal resistance of wheat to bunt, since this work was summarised by Humphrey and Woolman (7), and by Reed in 1924 (15).

The pioneer in this as in other aspects of wheat breeding was Farrer in Australia, and as the outcome of his work we have the relatively resistant varieties Genoa and Florence (2, 13).

In Germany the most extensive studies in this problem were made by Von Kirchner, who tested for bunt resistance during the period 1903-1916 360 varieties and selections of cultivated wheats. Considering the species as a whole, *T. durum, polonicum* and *monococcum* showed the highest resistance, but infection of one or more varieties of these species was obtained; while within each of the species *T. compactum, turgidum, spelta, dicoccum,* and *vulgare*, several varieties were found of marked susceptibility. Among varieties of *T. vulgare* Fürst Hatzfeld, Hohenheimer No. 77 and Beardless Odessa were exceptionally resistant, but none were found to be immune.

More recently in Germany a number of winter wheat varieties were tested for bunt resistance by Zade (20). Among fifty-six varieties only one, Heils Dickkopf, showed high and consistent resistance to bunt over a four seasons' trial. This variety, together with two others which showed a weaker resistance, were included in the experiments described below.

In 1918 the Australian resistant variety Florence was found to be highly resistant in some American trials (4), and at the same time certain selections of Turkey, a red Crimean wheat, remained almost free from infection under conditions which produced over 70 per cent. infection in susceptible varieties. A highly resistant and promising variety, Ridit, is the outcome of the cross Turkey x Florence, which was made at that time and studied by Gaines (4, 5).

An extensive search for bunt resistant varieties of wheat was made in America during the years 1918-20; nearly all the commercial varieties of wheat grown in the United States were tested at more than one station and numerous samples from Australia, India and South Africa were also included. Three

strains of White Odessa, nine selections from Turkey and the varieties Ridit, Florence and Banner Berkeley proved to be highly resistant to bunt (*Tilletia tritici*), while strains of Hussar and Martin, both varieties of common wheat, appeared to be actually immune (19). These varieties have remained free from infection in all subsequent trials in the United States and may be regarded as completely resistant to all collections of *Tilletia tritici* so far investigated in that country.

The genetics of bunt resistance have been studied by Gaines (5), Gaines and Singleton (6) and Briggs (1). Gaines, working with the highly resistant varieties Turkey and Florence, showed that in some wheat varieties bunt resistance is not a simple Mendelian unit character. If Mendelian, it is composed of multiple factors, and apparently different wheats possess different kinds of resistance (5). Briggs, using the completely resistant forms Martin and Hussar in crosses with highly susceptible varieties, found that resistance to bunt was completely dominant in Martin and almost completely dominant in Hussar. He concludes that the two varieties are apparently not exactly similar in their resistance to bunt, resistance in Hussar being due probably to more than one Mendelian factor (1).

From the genetical work already published one may conclude that it should not be difficult to use these immune varieties of wheat in breeding for bunt resistance.

II. Experimental Data and Discussion of Results.

The same method of testing any particular line selection or variety of wheat was used throughout the series of experiments described in the present paper. Samples of the grain to be tested were shaken with excess of bunt spores, the surface of the grain thus treated being appreciably darkened by large numbers of spores adhering to it. In the first experiment (harvest year 1924) the spores were taken from an English farm crop of Benefactor. In the subsequent years a spore collection was used which came originally from a Welsh crop of April Bearded wheat and was propagated at the station on Hen Gymro in 1925 and on various varieties in 1926.[2]

The grain thus contaminated was sown under field conditions in five-foot drills at the approximate rate of four grain per inch. Every grain sample under test was sown in duplicate, with the exception of those included in the March sowing, 1925 (Table II).

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[2] No significant difference was observed in the infection capacities of the two collections employed, but the experiments were not designed to test this point critically.

In 1924 and 1926 the plants from each row were pulled by hand at harvest and divided into three groups as follows :—

1. Plants bearing heads containing only healthy grain.
2. Plants bearing both healthy and bunted heads.
3. Plants bearing only heads with bunted grain. Partially infected heads were classified as " bunted."

The plants in each group were counted and recorded, and an estimation was also made of the number of healthy and bunted heads in each row. In 1925 the rows were cut at ground level and the percentage of disease was estimated only on the basis of bunted heads. It is evident from the tables that where estimations were made by both methods the figures show in most cases good agreement. Considerable divergence only occurred when the number of plants was unusually small, with the result that certain plants had space for excessive tillering. On the whole the figures given by estimating the percentage of bunted plants are slightly higher than those obtained when the heads alone are used as a basis for estimation. In 1926 (Table III) the greatest divergence between the two methods was 14 per cent. (April Bearded). Taking the average of the same fifty-six lots we have :—

Percentage bunted plants	...	...	73
Percentage bunted heads	...	...	72

In 1924 the corresponding figures for Hen Gymro selections were 69 per cent. and 65 per cent.

It will be convenient to consider the results under three headings :—

1. Pure line selections of Hen Gymro.
2. Foreign varieties selected for bunt resistance.
3. Common British varieties.

The results are summarised in Tables I, II and III.

1. *Pure line selections of Hen Gymro.*

In 1924 twenty-two pure line selections were tested for bunt resistance by the method outlined above, all the lots being sown on the same date, 6th February, 1924.

The range of infection throughout the experiment was 49-85 per cent. on an estimation of infected plants, 46-84 per cent. on an estimation of bunted heads (Table I). Although there was an apparent difference between the resistance of one line and another the results did not offer grounds for hoping that a highly bunt-resistant strain might be discovered by this method. It was decided, however, to repeat the trial in the following season with

the same lines and to include also eighteen other selections not previously tested. The grain was contaminated and sown on 4th November, 1924.

In the harvest year 1925 the infection was slightly lower than in the previous season. The average for all lines of Hen Gymro tested was 53 per cent.; the range among forty selections was 27-72 per cent., the estimation being made on the basis of bunted heads.

Considering lines tested in both seasons, the results do not show in all cases close agreement; certain lines which appeared to be relatively resistant in 1924 were found to be somewhat heavily infected in 1925. While a more extensive study might possibly reveal certain small but real differences in regard to bunt resistance between pure line selections of Hen Gymro wheat, it was not considered to be a useful subject for further investigation, since not a single selection in either season showed outstanding resistance. Such differences as appeared in the results were probably accidental departures from an average figure, which, under the conditions of the 1924-25 experiments, seems to lie between 50 per cent. and 70 per cent. This view is confirmed by the following result, obtained in 1926 when two lots were again tested, which showed respectively the highest and the lowest infection in a two year average in 1924-25 :—

Station No.	*Average 1924-25.*	*Percentage bunted heads 1926.*
150	83	80
378	76	81

In Table I the selections have been grouped according to ear characters, but it is evident that no correlation was found to exist between morphological features and resistance to bunt.

Since the method of pure line selection appears in the matter of bunt resistance to offer so little hope of success, breeding experiments have been started with the object of trying to introduce resistance by crossing selected lines of Hen Gymro with certain of the resistant varieties of *Triticum vulgare*, which will be discussed in the following section.

2. *Foreign varieties selected for bunt resistance.*

By the courtesy of Dr. Zade and Dr. Gaines, to whose work reference has already been made, samples were obtained in 1924 and 1925 of certain varieties of common wheat, which had been especially marked in their experiments for relatively high bunt resistance. These varieties have been tested three or four times

in the seasons 1924-26, together with certain British varieties which were included for comparison. The British varieties were not selected from any definite knowledge of their resistance or susceptibility to bunt. The data from four experiments are summarized in Table II.

TABLE I.

Showing the relative susceptibility to bunt of pure line selections of Hen Gymro wheat, 1924-25.

Ear Characters.	*Station No.*	1924 *per cent. bunted plants.*	1924 *per cent. bunted. heads.*	1925 *per cent. bunted heads.*	*Average 2 years per cent. bunted heads*
Bearded, red, smooth glumes ..	194	58	55	53	54
,, ,, ..	195	75	76	48	62
,, ,, ..	196	70	56	43	50
,, ,, .	285	78	67	63	65
,, ,, ..	501	—	—	61	—
,, ,, ..	502	—	—	50	—
Bearded, red, rough glumes	206	66	55	66	61
,, ,, ...	209	73	68	43	56
Bearded, white, smooth glumes ..	215	75	72	43	58
,, ,, ..	219	64	61	65	63
,, ,, ..	292	49	46	49	48
	354	81	81	36	58
,, ,, ..	467	—	—	52	—
,, ,, ..	469	—	—	72	—
,, ,, ..	470	—	.	50	—
,, ,, ..	378*	82	84	67	76
Bearded, white, rough	357	77	78	48	63
Semi-bearded, red, smooth	513	—	—	57	—
,, ,, ,, ...	520	—	—	56	—
,, ,, rough	505	—	—	43	—
Beardless, red, smooth glumes ..	140	68	66	54	60
,, ,, ..	148	63	62	59	61
,, ,, ..	150	44	38	27	33
,, ,, ..	326	63	59	45	52
,, ,, ..	489	—	—	56	—
,, ,, ..	490	—	—	51	—
,, ,, ..	494	—	—	66	—
,, ,, ..	496	—	—	65	—
Beardless, red, rough glumes	157	76	62	59	61
Beardless, white, smooth glumes..	165	78	70	53	62
,, ,, ..	171	65	69	51	60
,, ,, ..	473	—	—	55	—
,, ,, ..	474	—	—	57	—
,, ,, ..	480	—	—	56	—
,, ,, ..	481	—	—	46	—
,, ,, ..	484	—	—	59	—
Beardless, white, rough glumes ..	178	75	82	41	62
,, ,, ..	274	60	46	65	56
,, ,, ..	277	85	73	37	55
,, ,, ..	522	—	—	61	—
Average	—	69	65	53	58

* Glumes pale red.

In 1924 the rows of wheat in this experiment were unfortunately attacked somewhat severely by wireworm, and the number of plants which survived until harvest was too small to admit of reliable conclusions in all cases. Moreover, two of the

samples, Ridit and Turkey (and possibly Hussar) were apparently not free from impurity. The results, nevertheless, are not without interest. Martin remained completely bunt-free under conditions which resulted in 82 per cent. of bunted plants in one line of Hen Gymro and 14-52 per cent. bunt in other common British wheat varieties.

In the following season two sowings were made. On the 4th November, 1924, the same varieties were sown again, the seed in this case being taken from the healthy plants of the 1924 experiment. Three samples from Germany were then included for the first time.

In this trial two lines of Hen Gymro gave 65 per cent. and 67 per cent. of bunted heads, Pommersche and Kirches (Germany) gave respectively 72 per cent. and 67 per cent., while eight varieties commonly grown in the British Isles gave 6 per cent.—35 per cent. Ridit, Florence and Turkey, with 3 per cent., 7 per cent. and 17 per cent. bunt, showed a certain degree of resistance, while Hussar and Martin were entirely bunt-free. Heils Dickkopf, with 20 per cent. bunt, was distinctly more resistant than the other German varieties, a result which agrees with that obtained by Dr. Zade in Germany.

In the same season a second sowing was made on 10th March, 1925, new samples of seed of the American varieties having been received for trial, together with White Odessa, which was then tested in Wales for the first time. In this experiment the highest figures for bunt were given by two spring varieties, Red Marvel and April Bearded, which were almost completely infected, producing respectively 87 per cent. and 92 per cent. of bunted heads. Pommersche and Kirsches were again relatively susceptible with 31 per cent. and 50 per cent., while Heils Dickkopf with 4 per cent. was highly resistant. Florence, with 41 per cent., was distinctly less resistant than in the previous November sowing. The British varieties, Benefactor, Little Joss, Cook's Wonder and Hen Gymro (219), showed surprisingly low bunt infections when compared with results obtained in 1926 from grain sown in November. White Odessa and Turkey showed high resistance. Ridit, Hussar and Martin gave only healthy plants.

In 1926 the same varieties were again studied for bunt resistance from sowings made on 10th November, 1925. In this trial strong infection was obtained with Kirsches, Pommersche and the British varieties, which showed a range of 56 per cent.—88 per cent. bunted plants. In comparison with these, Florence, Heils Dickkopf and Turkey (38 per cent., 18 per cent. and 12 per

cent.) were more resistant, White Odessa and Ridit (9 per cent. and 2 per cent.) were highly resistant, and Hussar and Martin completely resistant, again producing only healthy plants. These two varieties have, therefore, with the doubtful exception of Hussar in 1924, remained bunt-free in four trials extending over three seasons and conducted under conditions which did not fail to produce in certain other varieties very high percentages of disease. Ridit, Turkey and White Odessa have shown marked resistance in three trials (1925-26), and results with these varieties also agree very closely with those obtained in America. This, undoubtedly, is the result of first importance arising out of the present series of experiments, since it appears to indicate that varieties showing high resistance to bunt over a long period in America, and proving of value there in breeding experiments, behave in this same way to *Tilletia tritici* in this country and may possibly be used here also for the production of bunt-resistant varieties.

This result was not altogether anticipated in view of the increasing number of parasitic fungi which, on investigation, prove to be differentiated into several distinct biologic species, to which varieties of cultivated plants show varying degrees of resistance. Thus it was found recently that certain oat varieties resistant to *Ustilago laevis* in America were markedly susceptible to Welsh collections of the same fungus (14, 17). Fortunately for the plant breeder *Tilletia tritici* appears to be less variable in this respect, and up to the present time no well established biologic species of this fungus have been discovered.[3] Thus the variety Florence, which was bred in Australia for bunt resistance, has proved of value as a bunt-resistant variety in America. It appears now from the results of the above experiments that Martin and Hussar, which are immune to bunt in America, show the same reaction to the disease in this country and may conceivably be of value here in breeding work.

Interesting in the same connection is the behaviour in these trials of the three German varieties, Pommersche, Kirsches and Heils Dickkopf. The results agree in so far as Heils Dickkopf is concerned, since this variety in Wales and in Germany showed relatively high resistance. With the two varieties, Kirsches and Pommersche, rather higher results were obtained in Wales (1925-26) than were obtained in Germany by Dr. Zade (1920-23), but this discrepancy in results might be due to seasonal variation,

[3] Results indicating that biologic species of *Tilletia tritici* do exist have been obtained in America by Faris (8).

since Dr. Zade informs me by letter that higher figures for infection were obtained in 1924-25 than in the earlier series of experiments reported on in 1923 (20).

TABLE II.

Showing the relative susceptibility to bunt (*Tilletia tritici*) of certain wheat varieties from Germany, United States and Britain, 1924-26.

Source of Seed and Variety.	*Station No.*	1924 *Feb. sown per cent. bunted plants.*	1924 *Feb. sown per cent. bunted heads.*	1925 *Nov. sown per cent. bunted heads.*	1925 *March sown per cent. bunted heads.*	1926 *Nov. sown per cent. bunted plants.*	1926 *Nov. sown per cent. bunted heads.*
Germany:							
Heils Dickkopf	589	—	—	20	4	18	15
Kirsches	590	—	-	67	50	84	86
Pommersche	591	-	—	72	31	62	58
U.S.A.:							
Florence	579	(35)	(10)	7	—	—	-
	612		—	-	41	38	20
White Odessa	607	—		—	7	9	4
Ridit	580	28*	32*	3	—	-	—
	610	—	—	-	0	2	1
Turkey	578	20*	30*	17	—	—	—
	611	—	—	—	4	12	11
Hussar	581	(8)	(4)	0	-	—	
	609	—	—	—	0	0	0
Martin	582	0	0	0	—	—	—
	608	—	—	—	0	0	0
Britain:							
Yeoman	120	25	26	26	—	63	54
Victor	121	(20)	(35)	24	—	75	74
Benefactor	126	14	11	20	10	62	62
Squarehead's Master	123	—	—	6	—	78	78
Standard Red	128	(47)	(45)	22	—	80	78
Little Joss	127	52	54	35	13	56	47
Svalof Iron	561	46	37	19	—	69	71
Cooks Wonder	571	(30)	(15)	35	15	80	81
Hen Gymro	378	82	84	67	—	83	81
	219	64	61	65	15	65	67
Red Marvel	686	—	—	—	—	81	80
	19	—	—	—	87	—	—
April Bearded	606	—	—	—	92	—	—

* Samples 578 and 580 gave rise to a mixed population. Figures marked ( ) are based on only ten to twenty plants owing to a severe attack of wireworm in March. In the case of Hussar (581) only thirteen plants survived, of which one was bunted. It is, of course, possible that this plant was a rogue, since the variety remained immune in three subsequent trials, each of which involved a large number of plants.

3. *British wheat varieties.*

In 1924-25 certain of the British varieties included in the trials with foreign samples gave somewhat unexpectedly low percentages of infection. So far as the writer is aware no extensive trial has been made in this country to determine the relative bunt resistance of wheat varieties commonly grown in Britain, but it appears to be generally held that certain varieties such as Squarehead's Master, Little Joss and Benefactor are highly susceptible to bunt. In these trials Squarehead's Master produced in the first two seasons only a small number of

plants, but these were almost completely bunt-free.[4] Benefactor, Standard Red and Svalof Iron also gave low figures when compared with a variety such as Hen Gymro. The writer decided, therefore, to obtain a larger number of samples of British wheats and to test these for bunt resistance under conditions made as favourable as possible for infection. Fifty-six samples were obtained, contaminated with bunt spores, and sown on 10th November, 1925. A period of unusually cold weather followed the date of sowing and the germination was delayed for nearly six weeks. In most cases, however, a good stand was made and closely concordant results were obtained from the duplicate rows. The results are given in Table III, from which it will appear that the conditions were particularly favourable for infection by bunt. One sample (Fortuna) showed 91 per cent. of bunted plants, nineteen of the winter-sown wheats gave over 80 per cent. of bunt, and the lowest figure in the whole experiment was Little Joss (127) with 56 per cent.

The varieties have been grouped on the colour and morphology of grain and ear, but there is no indication in these data of a correlation between such characters and resistance to bunt. Taking the average of all white-grained and all red-grained varieties the same figure, viz., 75 per cent. of bunted plants, is obtained for the two groups. In America also, taking the average of a large number of samples, the soft red winter wheats and the white-grained winter wheats showed close agreement, having, respectively, 60.2 per cent. and 58.8 per cent. infection, while the hard red winter wheats proved to be relatively more resistant, with only 22.7 per cent. infection (19). The latter group included several selections of Turkey, which, as previously stated, is relatively a very resistant variety. Of British wheats tested in Wales, Yeoman is undoubtedly the hardest red wheat, and it is perhaps worthy of record that among eight samples included in the trial the bunt infection varied between 60 per cent.—67 per cent., a range of figures undoubtedly high, but one which falls below the average for the varieties taken as a whole. It should be understood that these varieties were sown on the same day and under the same conditions as the resistant American varieties

[4] This raises the question as to a possible selective action of environmental factors on a mixed population of bunted and healthy plants. Some evidence has been brought forward which indicates the relatively low rate of establishment of bunt-contaminated grain as compared with bunt-free grain (16, 18). Although exact data are not available, there is some evidence that in the 1926 experiment "winter killing" was less pronounced than in 1924-25 and the percentage of bunted plants was remarkably high in certain varieties which gave in the two previous years relatively few plants and low percentage of disease. Experiments to test this point further are in progress.

TABLE III.

Showing the relative susceptibility to bunt of wheat varieties supplied by firms in the British Isles, 1926.

*Name of variety supplied with sample.**	*Station No.*	*Percent. bunted plants.*	*Percent. bunted heads.*
A. WINTER SOWN.			
1. *Triticum vulgare* var. *albidum*†			
Dutch Million ...	1	57	54
Million III ...	708	74	65
Benefactress ...	675	66	68
White Standup ...	702	83	87
Standup White ...	691	84	79
Double Standup White ...	716	70	66
Old Brooker's White Standup	667	80	78
White Wonder ...	683	85	79
Wilhelmina ...	668	81	82
Wilhelmina ...	710	87	85
Victor ...	121	75	74
Victor ...	680	78	81
Average ...		77	75
2. *T. vulgare* var. *alborubrum*			
New Empire ...	694	73	72
3. *T. vulgare* var. *leucospermum*			
Benefactor ...	126	62	62
Average white grained varieties ...		75	74
4. *T. vulgare* var. *milturum*			
Little Joss ...	127	56	47
Little Joss ...	671	71	65
Little Joss ...	684	65	64
Little Joss ...	709	66	62
Standard Red ...	128	80	78
Standard Red ...	664	80	75
Standard Red ...	679	72	70
Standard Red ...	689	77	73
Squarehead Master ...	123	78	73
Squarehead Master ...	665	77	79
Squarehead Master ...	669	80	78
Squarehead Master ...	677	77	69
Squarehead Master ...	687	77	79
Squarehead Master ...	692	85	84
Squarehead Master ...	701	87	87
Squarehead Master ...	705	67	69
Red Chaff Squarehead ..	718	63	61
Red Standup ...	700	80	83
Average ...		74	72
5. *T. vulgare* var. *lutescens*			
Yeoman ...	120	63	54
Yeoman ...	681	67	65
Yeoman ...	695	66	71
Yeoman ...	717	60	57
Yeoman II ...	658	66	66
Yeoman II ...	688	63	58
Yeoman II ...	712	67	72
Yeoman King ...	708	64	68

TABLE III (Continued).

Showing the relative susceptibility to bunt of wheat varieties supplied by firms in the British Isles, 1926.

*Name of variety supplied with sample.**	*Station No.*	*Percent. bunted plants.*	*Percent. bunted heads.*
5. *T.vulgare* var. *lutescens* (con.)			
Iron ...	561	69	71
Iron ...	682	76	77
Iron III ...	663	74	77
Iron III ...	714	77	77
Harvester ...	693	79	76
Harvester ...	690	74	70
Foch ...	674	79	76
Crown ...	659	84	82
Rector ...	666	73	72
Rector ...	676	66	62
Chevalier ...	661	78	80
Chevalier† ...	715	87	86
Browick ...	673	61	48
Stormproof ...	698	89	87
Croxten Champion ...	699	85	86
Iduna ...	711	60	58
Red Admiral ...	704	58	56.
John Bull ...	672	78	75
Fortuna ...	713	91	91
Twenty-one ...	707	78	76
Red Marvel‡ ...	686	81	80
Average ...		73	72
6. *T.vulgare* var. *ferrugineum*			
New Bearded ...	685	65	58
Average red grained varieties		75	71
7. *T.turgidum* var. *dinurum*			
Rivetts ...	670	60	67
8. *T.turgidum* var. *iodurum.*			
Blue cone ...	706	63	65
9. *T.vulgare* mixed types			
Hen Gymro (pure line selections)	378	83	81
Hen Gymro (pure line selections)	219	65	67
Hen Gymro (pure line selections)	150	72	80
Hen Gymro (pure line selections)	484	78	83
B. SPRING SOWN.			
1. *T.vulgare* var. *lutescens*			
Red Marvel‡ ...	723	87	86
2. *T.vulgare* var. *ferrugineum*			
April Bearded ...	722	80	94
Average fifty-six lots ...		73	72

* The samples have been grouped on ear characters by the writer, but no attempt has been made to deal with the problem of synonyms. Obvious "rogues" (in all cases rare) were excluded from the results.

† The names of varieties are taken from "The Wheat Plant", by J. Percival.

‡ The glumes in Red Marvel are very pale red. This variety is classified as *milturum* by Percival.

dealt with in the previous section of this paper, two of which remained completely bunt-free. It is evident that in comparison with these the British wheat varieties tested in Wales in this experiment are one and all highly susceptible to bunt when grown under conditions favourable for infection.

III. Biological Observations.

In addition to the data furnished by these experiments, and already discussed, as to the varietal resistance of wheat to bunt, the results present certain features which are of interest from the point of view of the interaction of host and parasite.

1. *Partially diseased ears.*

When the resistance of varieties was estimated on the basis of percentage infected heads, ears which showed one or more bunted grain were classified as diseased. From the examination of some thousands of heads involved in the above experiment it became evident that in most varieties partially diseased ears were comparatively of infrequent occurrence, the infected heads bearing in nearly every case bunted grain only. In 1925 two varieties, Heils Dickkopf and Pommersche, seemed to be outstanding exceptions to this rule, and an estimation was made, therefore, of the percentage of healthy grain occurring in heads obviously invaded by the parasite. For comparison a few other varieties were examined in the same way and further data were obtained in 1926 (Table IV).

Three varieties only, Florence and the two named above, were outstanding in this respect, from 30 per cent.—45 per cent. of the grain produced by infected heads being apparently free from disease. Heils Dickkopf and Pommersche showed in addition an appreciable number (7 per cent.—20 per cent.) of grain clearly invaded by the fungus but not completely destroyed. In some cases the fungus spores were restricted to small tumour-like swellings on the upper part of the grain and the embryo was uninjured and capable of germination.[5]

The close agreement of the data obtained in the two seasons appears to suggest that incomplete invasion of the ear by the fungus is characteristic of the particular variety of wheat and is a further manifestation of relative resistance to the parasite.

[5] The separation into "healthy", "partially bunted" and "completely bunted" grain was made by eye examination and is therefore only relative. A grain was classed as "partially bunted" when approximately half of the endosperm was hard and white. A germination of 76 per cent. was obtained when 50 "partially bunted" grain were sown on sand.

Florence and Heils Dickkopf, which showed the highest percentage of healthy grain among infected ears, are varieties which take a relatively high place when resistance is judged by the percentage of bunted plants or heads. Pommersche, on the other hand, produced in these experiments a high percentage of bunted plants and heads, but over 30 per cent. of the grain from infected heads was healthy. In all other susceptible varieties studied the proportion of healthy grain produced by infected ears was low—certainly not above 2 per cent. (Table IV). It is suggested that the phenomenon of partially diseased ears might possibly prove of interest in genetical studies of bunt resistance.

TABLE IV.

Showing the percentage of healthy, partially bunted and completely bunted grain in heads of wheat infected by *Tilletia tritici*.

VARIETY.	*Station No.*	*Year.*	*No. of heads examined.*	*Total No. of grain*	*Healthy grain per cent*	*Partially bunted grain per cent*	*Completely bunted grain per cent.*
Heils Dickkopf	589	1925	20	319	45.4	13.5	41.1
,, ,, ...	589	1926	30	356	43.5	18.8	37.7
Pommersche........	591	1925	20	497	36.3	15.5	48.2
,, ...	591	1926	50	810	33.1	6.7	60.2
Florence	612	1926	25	399	39.6	1.0	59.4
Turkey	611	1926	6	122	6.6	0.0	93.4
Kirsches	590	1925	20	386	3.9	1.0	95.1
,, ...	590	1926	50	1530	.8	0.0	99.2
Rivetts	670	1926	20	1428	1.9	0.0	98.1
Benefactor	126	1925	20	847	.7	.1	99.2
,, ...	126	1926	25	1272	1.4	0.0	98.6
Little Joss	684	1926	30	886	.9	0.0	99.1
Dutch Million	1	1926	25	1081	.7	0.0	99.3
Yeoman	--	1926	175	4077	.5	0.0	99.5
Wilhelmina	710	1926	30	770	.3	0.0	99.7
Standard Red	679	1926	30	897	.2	0.0	99.8
Hen Gymro	—	1925	50	—	0.0	0.0	100.0
,, ,, ...	150	1926	50	1373	0.0	0.0	100.0
Svalof Iron	663	1926	30	1210	0.0	0.0	100 0

2. *The influence of Tilletia tritici on growth in height.*

That the fungus exercised a retarding influence on growth in height was evident in all the varieties studied in this series of experiments, the bunted tillers being noticeably shorter in the stem than those bearing healthy heads. In 1925 measurements were made on fifty healthy and fifty bunted tillers from each of eleven Hen Gymro selections and five other varieties. The percentage differences in height in favour of the tillers bearing healthy heads are given by the following figures :—

Hen Gymro (average of eleven selections) 27 per cent.
(Range 20 per cent.—55 per cent.).
Pommersche ... ... 28 per cent.
Heils Dickkopf ... ... 24 per cent.
Standard Red ... ... 18 per cent.
Yeoman ... ... 38 per cent.
Cook's Wonder ... ... 20 per cent.

The range of figures cannot be taken as indicating real differences between the behaviour of the one variety and another, since they are based on one set of measurements only, but it is of interest to note that the growth of the relatively resistant variety Heils Dickkopf was in this case retarded to the same extent as certain of the more susceptible varieties. Experiments dealing directly with the influence of *Tilletia tritici* on vegetative growth have been discussed in a separate paper (18).

IV. Summary.

1. Of forty pure line selections of Hen Gymro wheat studied for susceptibility to bunt none showed outstanding resistance. No correlation between morphological characters and relative susceptibility was indicated by the results.

2. Of sixty-five samples, including some thirty-two varieties of British wheats, tested in one season for bunt resistance all showed relatively high susceptibility (56 per cent.—91 per cent.).

3. Two varieties, Martin and Hussar, both immune to *Tilletia tritici* in America, appear to be completely resistant also to bunt in Wales. White Odessa, Ridit and Turkey, also varieties of *T. vulgare*, which have shown high bunt resistance in America, proved to be relatively resistant in these trials.

4. Heils Dickkopf, a variety which has shown resistance to bunt in Germany, was relatively resistant in Wales.

5. Three varieties, Florence, Heils Dickkopf and Pommersche, developed a considerable proportion (83 per cent.—45 per cent.) of healthy grain among the bunted grain of infected heads. In the majority of varieties studied the invasion of the infected ears was usually complete.

6. The experiments indicate the need for improving British wheat varieties as far as bunt resistance is concerned, and at the same time suggest the possibility of introducing resistance by crosses with the immune varieties Hussar and Martin.

7. The behaviour in Wales of certain foreign wheat varieties of known bunt resistance gives support to the view that *Tilletia tritici* is not a fungus with many highly specialised biologic species.

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A SURVEY OF THE INSECT PESTS OF MID AND WEST WALES.

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The following notes on the chief insect pests of cultivated crops in Mid and West Wales are the result of a survey of the area which has been carried out during the last four years. Since the tract of country surveyed comprises the following seven counties—Brecon, Cardigan, Carmarthen, Merioneth, Montgomery, Pembroke and Radnor,—with a total area of 4,859 square miles, a survey of four years' duration cannot claim to be exhaustive. It has, however, been carried out in detail sufficiently full to enable the making of a fairly complete record of the insect pests of the area.

A knowledge of the prevalent insect pests of the area is necessary before adequate steps can be taken to suppress them, and the chief reasons for the inclusion of this record in the *Welsh Journal of Agriculture* are, firstly, that no such record has previously been made, and secondly, it is hoped that farmers and others will help to make the record complete by communicating with the writer whenever they need advice on the suppression of insect pests. Such advice, which, needless to say, is free of charge, will be gladly given.

The figures comprising the following table are taken from *The Report on the Acreage under Crops*, Vol. LIX, Part I, issued

by the Ministry of Agriculture. They give an indication of the type of agriculture existing in the seven counties referred to above, to which they relate, the date of compilation being June, 1924 :—

	Total acreage.
Total Acreage (excluding water)	3,109,854
Acreage under Crops and Grass[1]	1,681,988
Arable land	404,368
Permanent Grass for Hay	345,185
Permanent Grass not for Hay	902,435
Rough Grazing	1,070,376
Clover and Rtn. Grass for Hay	96,746
Clover and Rtn. Grass not for Hay	64,546
Wheat	15,312
Barley	40,093
Oats	113,120
Mixed corn	14,537
Potatoes	12,838
Turnips and Swedes	25,980
Mangolds	5,665
Cabbage, etc., for Fodder	8,371
Small fruit[2]	216
Orchards	2,004

As would be expected, the figures show clearly the great preponderance of grassland in the area, whilst other important features are the great importance of oats as compared with any other crop, and the very small acreage under fruit.

In the following account the pests are grouped according to the type of crop attacked, as it is considered that such an arrangement gives a clearer view of the position of the area as regards insect attack, than an arrangement based for example upon the natural orders to which the pests belong.

Pests of Cereals.

WIREWORMS.—*Agriotes spp.* and *Athous spp.*

Wireworms during 1923-1925 were one of the most serious pests with which the farmers of the area had to contend; they were more prevalent on the lighter shaly and " brashy " soils so common in many parts of Wales. As is to be expected, the greatest damage is to the first two crops after an old ley, and as those two crops are almost always spring oats, a crop of prime importance in Wales, the control of wireworm attack is a matter to which the farmers of Wales should devote serious attention. In 1926 wireworm damage was very considerably less, but, on the other hand, the adult beetles were particularly numerous. This indicates that wireworm damage will probably gradually increase, to again reach a maximum in four or five years' time. There is no doubt that slight alterations in the cultural practices

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1 Not including rough grazing.
2 Including small fruit in orchards.

prevalent would be of no little value in reducing the ravages of these pests, especially on those farms which suffer yearly from their depredations. Observations made by the writer tend to show that "brairding" power (i.e., capacity for rapid and vigorous early growth) and tillering capacity (i.e., power of producing secondary shoots) are both important factors influencing the power of any particular variety of oats to withstand and grow away from wireworm attack, as in oat variety trials which have been attacked by wireworms, those varieties which brairded well and tillered well were considerably less damaged than varieties less efficient in these respects. Wireworm damage has also been observed in varying degrees of intensity to wheat and barley, any case of severe damage almost invariably occurring when the crop was either the first or second crop after an old ley.

The most commonly occurring species are *Agriotes obscurus* L., *Agriotes sputator* L. and *Athous haemorrhoidalis* F.; *Agriotes lineatus* L. and *A. pallidulus* Ill. also occur.

Lema melanopa L.

The distribution of this beetle during the period under review is of much interest. In 1923 both adults and larvae (the latter feeding on oat leaves) were very common in many localities, the Aberystwyth district in particular. From 1924 to 1926 both stages were very scarce and difficult to find, even in fields adjoining those in which they were so plentiful in 1923. It seems probable that the very bad weather conditions of the 1923 summer were responsible for the destruction of large numbers of the larvae.

LEATHERJACKETS.—*Tipula spp.*

In the years 1923 and 1924 leatherjackets were not responsible for much damage to cereals. Attacks on wheat, barley and oats were recorded in various localities, the worst being 25% damage to barley in North Pembrokeshire after a one-year clover ley. The year 1925, however, was characterised by the large amount of damage caused by these pests to young cereals, particularly to oats. Several cases of total failure entailing re-seeding with barley were recorded, particularly from Brecon and Radnor. Species which have been recorded are *Tipula oleracea* L., *T. paludosa* Meig., *T. lateralis* and *Pachyrrhina* sp.

THE FRIT FLY.—*Oscinella frit* Linn.

Although the frit fly is stated to cause much loss in several districts in some seasons, no appreciable damage has been

recorded during the years under review. In 1923 the pest was noted on young spring oats on most farms visited, but the percentage attack was always extremely low. From 1924 to 1926 damage was to all intents and purposes non-existent, and in 1925, during a survey of some thirty farms in districts in Montgomeryshire, reputed to suffer considerably in some seasons, no trace was found of second brood attack. Many complaints have been received each year of " blindness " in oats, particularly from South Pembrokeshire, but in all cases examined the blindness was almost entirely physiological, and *O. frit* was present only to a very small degree.

THE GOUT FLY.—*Chlorops taeniopus* (Meig).

Although widely distributed the gout fly does not appear to be a serious pest of barley in the area. The heaviest attack noted was near Aberystwyth in 1923, when a 4% loss was sustained.

ST. MARK'S FLY.—*Bibio Marci* L.

The larvae of *B. Marci* have only once been recorded as injurious to cereals in the area. The attack occurred on wheat in the Aberayron district in 1923, but since wireworms and leatherjackets were also present an assessment of the damage due to *Bibio* larvae was impossible.

THE COMMON RUSTIC MOTH.—*Apamea oculea* Gn.

The larvae of this moth are not common. They have been recorded in the Tregaron, Llangeitho and Aberystwyth districts, in small numbers only, in young oats.

CORN GREENFLY.—*Aphides.*

No serious infestations of corn greenflies have occurred during the years under review. The species which have been recorded are :—*Aphis avenae F.* on barley; *Aphis padi L.* on wheat and oats; *Macrosiphum dirhodum* Walk. on oats; *Macrosiphum granarium* Kirby on wheat; and *Myzus festucae* Theob. on wheat.

" BLACK FLIES."—*Thrips cerealium.*

Slight attacks by this pest were recorded in 1925 on oats in the Aberystwyth and Pembroke Dock districts.

SLUGS AND SNAILS.

Slugs and snails have on several occasions been recorded as injurious to young spring oats. The damage invariably occurred alongside hedges, or ditches, or other damp situations in which

the pests breed. The most commonly injurious species are *Agriolimax agrestis* L. and *Helix virgata* D.C.

ENCHYTRAEIDAE.

These small worms of the earthworm family, whose economic status appears to be uncertain, were suspected by one farmer in the Llanuwchllyn district of being the cause of serious damage to oats. The worms were present in enormous numbers, and were in close association with the oat roots, but since *Ophiobolus cariceti* (*graminis*) (" take all " disease) was also present it was not possible definitely to ascribe damage to the enchytraeids. The matter was therefore tested during the following season by comparing the growth of two lots of Record oats grown in boxes, one box having been infected with enchytraeids from the farm in question, six worms to each oat plant, whilst the other box was kept uninfected as a control. At no time during the growing season was there any apparent difference between the two sets of plants, and at the end of the season no evidence was found of root injury to plants from the infected box. Further observations on the habits of these oligochaetes indicate a decided preference for decaying organic matter, and it seems probable that on the farm referred to above *Ophiobolus cariceti* caused decay of the oat roots and consequent attraction of the enchytraeids.

EAR COCKLES.—*Anguillulina tritici. S.*

This pest has been recorded from two districts only, Knighton and Henllan, the damage in both cases amounting to about 5%. Standard Red and Prize Prolific were the two varieties of wheat attacked.

Pests of Grassland.

THE ROSE CHAFER.—*Cetonia aurata* L.

The larvae of this chafer beetle have once been recorded as injurious to grassland, in Breconshire, near Merthyr Tydfil, where 50% of a four-acre permanent pasture was destroyed. Crude or " whizzed " naphthalene was successfully used to control the pest.

LEATHERJACKETS.—*Tipula spp.*

Leatherjackets do not appear to be a common pest of grassland in the area. Apart from a few cases of damage to golf greens and tennis lawns, the only severe damage recorded was in the Llanwnog district, to a permanent seeds mixture immediately following a very old pasture.

FEVER FLIES.—*Dilophus febrilis.* Linn.

The larvae of this fly did very considerable damage in 1925 to several greens on the Borth golf course. An application of commercial naphthalene completely destroyed the larvae.

THE YELLOW UNDERWING MOTH.—*Triphaena pronuba* L.

Larvae of the yellow underwing moth caused some damage to hybrid grasses on the Welsh Plant Breeding Station in 1928.

SLUGS.

Complaints of damage to pasture have been received from time to time.

Pests of Clover and other Legumes.

The study of clover pests has been interesting in that it has shown that failures to obtain good clover stands—the failures being not uncommon—are not necessarily always due to such factors as poor seed, lack of lime, lack of phosphate, etc., but that they are often due to pest attack in the seedling stage. This aspect has already been dealt with in a preliminary manner,[3] and it is hoped to treat of it more fully in the near future.

CLOVER WEEVILS.—*Apion spp.*

Clover apions are common throughout the area, often occurring in enormous numbers. Damage to foliage in the aggregate must be very appreciable, whilst in the seed producing districts the larvae of certain of the species are no doubt in some years responsible for an appreciable loss of seed. Of the species occurring in the area *A. apricans* Herbst. is not at all common. It has been taken in several localities, but always very sparingly, and has only been taken on clover. *A. assimile* Kirby and *A. trifolii* Linn. together represent at least 75% of the apion population of clover, *trifolii* being the more common. *A. trifolii* has also been taken sparingly on lucerne. *A. virens* Herbst. is fairly common on clover; *A. tenue* Kirby is uncommon. *A. nigritarse* Kirby and *A. dichroum* Bedel are fairly common on yellow suckling clover and white clover respectively. They are uncommon on other clovers. *A. pisi* F. was taken in enormous numbers on lucerne at Aberystwyth in 1924, and in less numbers in 1925. The crop is rarely grown in the area, so the distribution of the species is not known. It has also been taken on soya bean.

The weevils were most common in 1923, their numbers decreasing slightly in 1924 and again in 1925 and 1926.

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[3] *Welsh Journal of Agriculture*, Vol. II, 1926, pp. 221-228.

CLOVER LEAF AND ROOT WEEVILS.—*Sitones spp.*

These weevils, which are common and generally distributed throughout the area, appeared to be slightly more abundant in 1924 than in 1923. In 1925 they were, in some districts, extraordinarily numerous, particularly in the spring, when on one occasion thirty-seven weevils were taken from four red clover plants. *S. sulcifrons* Thunb. is by far the most common clover species, sometimes occurring in very large numbers. Although a certain amount of adult feeding takes place throughout the year, the most serious damage is done in the spring to the young clover seedlings and to the young spring growth of second and third year plants. *S. hispidulus F.* is fairly common on clover, but *S. lineatus* L., *S. crinitus* Herbst. and *S. flavescens* Marsh, whilst occasionally taken on clover, are all uncommon. On vetches *S. sulcifrons* Thunb. and *S. lineatus* L. have been taken, neither being common. On lucerne *S. lineatus* L. is the only species that has been taken. It is sometimes extremely abundant.

Phytonomus spp.

One of the interesting points brought to light during the survey of the area is that in some districts these weevils must be regarded as pests certainly of the same order as *Sitones spp.* Damage by adults and larvae to foliage and flowerheads has been noted, in some cases almost severe. In one case forty-seven larvae were taken from ninety-six flowerheads. *P. nigrirostris* F. is by far the most common species in the majority of districts, although in some cases *P. trilineatus* Marsh has been found to be almost equally abundant. *P. punctatus* F., *P. polygoni* L. and *P. rumicis* L. have all been taken on clover in small numbers, the two last named being probably accidental visitors.

Gastroidea polygoni L.

The occurrence of this beetle during the three years under review is of much interest. In 1923 it was exceedingly common around Aberystwyth and was suspected of damaging clover. In 1924 it was scarce and difficult to find, even in fields where it had been so plentiful the previous year. In 1925 it was again exceedingly abundant, particularly on the various species of polygonum. Since there appeared to be some doubt as to whether or not the beetle is responsible for clover injury, males and gravid females were caged with red clover plants. Oviposition was readily performed on the clover, but neither adult nor larval feeding took place.

Phyllobius viridiaeris Laich.

This leaf-eating weevil occurs on clover in most localities, but has never been found in numbers sufficiently large to cause material damage.

CLOVER MIDGES.

Three species of midge have been recorded in the area. The clover leaf midge, *Dasyneura trifolii* Low, which is not common, has been taken in the Aberystwyth and Montgomery districts. The clover seed midge, *Dasyneura leguminicola* Lint. appears to be generally distributed, but has never been found in numbers sufficiently large to cause appreciable diminution of the seed yield. The clover midge, *Amblyspatha ormerodi* Kieff. has only been once recorded, from Churchstoke, where practically all the clover on one farm was destroyed in the spring of 1924.

Phytomyza atricornis Meig.

This leaf miner, which has numerous hosts, occurs in small numbers on red clover in many districts. Whilst the usual habit of this species is to pupate in its mine, it is often found that when attacking clover it departs from that habit and pupates in the soil.

MOTHS.

The larvae or caterpillars of the following species of moths have been taken on red clover, chiefly around Aberystwyth, and in Montgomeryshire :—*Plusia gamma* L., the Silver Y; *Agrotis segetum* Schiff., the Turnip Moth; *Euclidia mi* Clerck., the Mother Shipton; *E. glyphica* L., the Burnet Companion; *Zygaena filipendulae* L., the Six Spot Burnet; *Zygaena lonicerae* Esp., the Narrow Bordered Five Spot Burnet; and *Zygaena trifolii* Esp., the Five Spot Burnet. The larvae have never, however, been found in numbers sufficiently large to make them economically important.

GREEN FLIES.

Five species of aphides have been recorded on red clover, mainly around Aberystwyth and in Montgomeryshire. Four of them, *Macrosiphum malvae* Mosely, *Macrosiphum pisi* Kalt., *Myzus circumflexus* Buckton, and *Myzus persicae* Sulz., attack the leaves and stems, the last named being the only one recorded in large numbers. The fifth species, *Anuraphis warei* Theob., attacks the flowerheads and has been the cause of heavy infestations around Aberystwyth and in Montgomery, doubtlessly causing a reduction of yield in the seed producing areas of the

latter district. *Megoura viciae* Kalt. was the cause of the worst aphid attack noted in 1924, Vetches at the College Farm, near Aberystwyth, being exceedingly heavily attacked.

PLANT BUGS.—*Capsidae.*

Four species of *Capsidae* are common on red clover—*Lygus pratensis* L., *Calocoris norvegicus* Reut. and Osh., *Miris calcaratus* Fall. and *M. laevigatus* L. They have been found in all districts visited, sometimes occurring in enormous numbers.

EARWIGS.—*Forficulidae.*

Have once been recorded as injurious to clover, having attacked flowerheads bagged up after pollination.

EELWORM.—*Tylenchus devastatrix* Kuhn.

One very light attack only has been recorded, near Aberystwyth.

SPRINGTAILS.—*Collembola.*

Often occur in enormous numbers on red clover and undoubtedly often contribute in no small degree to the failure to obtain good stands of clover seedlings. *Sminthurus viridis* L. is the only species which has been recorded in numbers.

SLUGS AND SNAILS.—*Mollusca.*

Are often injurious to young clover seedlings, particularly near hedgerows or woodland. Species which have been recorded as injurious in this manner are *Agriolimax agrestis* L., the Grey Field Slug; *Arion ater* L., the Large Black Slug; *Helix hortensis* and *H. nemoralis*, the Wood Snails.

Pests of Potatoes.

WIREWORMS.—*Agriotes spp.*

Wireworms are a very common source of damage to potato tubers; attacks are worst in foul, or recently formed allotments, or where potatoes form the first crop after an old ley.

POTATO FLEA BEETLES.—*Psylliodes affinis* Payk., *P. picina* Marsh.

The former flea beetle has been taken sparingly in many localities, but has never been recorded as the cause of appreciable damage; the latter is uncommon and not known to be injurious in the area.

POTATO GREENFLIES AND PLANTBUGS.

Greenflies, although widely distributed in the area, have never been found in large numbers in the field. They appear to be very scarce in the high lands of Merioneth. Since some or all of these insects are transmitters of virus diseases, the latter fact

is of great interest in view of the experimental seed production being carried out in the county. *Macrosiphum solanifolii* (Ashm.) is commonly distributed, but has only been recorded in numbers on sprouting potatoes at Aberystwyth. *Myzus persicae* (Sulz.) is the most common potato aphid, whilst *Myzus pseudosolani* Theob. is uncommon. *Lygus pratensis* L. and *Calocoris norvegicus* R. and S. are very common plant bugs on potatoes, and sometimes occur in enormous numbers.

LEAF HOPPERS.—*Eupteryx auratus* Linn., *Chlorita viridula* Fall.

These two leaf hoppers are of general occurrence throughout the area, but no heavy infestations have been recorded.

FROG HOPPERS.—*Philaenus spumarius* Lin.

Extremely common on potatoes, sometimes occurring in enormous numbers.

MILLEPEDES.—*Blanjulus pulchellus* Leach.

Occasionally most injurious to potato tubers, particularly in gardens and allotments.

EELWORM.—*Heterodera schachtii* Schmidt.

Not a common pest of potatoes; has been recorded only once, from the Knighton district.

SLUGS.—*Mollusca.*

Slugs are frequently the cause of serious damage to potato tubers. This was particularly so in 1926, when in very many districts the market value of the crop was greatly reduced.

Pests of Root Crops and Brassicae.

THE TURNIP GALL WEEVIL.—*Ceutorrhynchus pleurostigma* Marsh.

This pest appears to be of fairly general distribution, but heavy attacks have been noted in one locality only—North Pembrokeshire, in the Newport and Fishguard districts.

TURNIP FLEA BEETLES.—*Phyllotreta spp.*

Turnip flea beetles are universally distributed throughout the area, and are in some seasons responsible for considerable loss. Their ravages appear to be worst on the lighter sandstone or marl soils found in parts of Radnor, Carmarthen and Pembroke, where total failures of swedes from this cause are common. The beetles were considerably more abundant in 1925 and 1926 than in the two previous years, and, where swede germination coincided with the period of maximum occurrence, caused much damage. By far the most common species is *Phyllotreta undulata* Kuts., which is responsible for almost all the damage. Other

species, which occur in small numbers, are *P. nemorum* L., *P. sinuata* Steph., *P. nigripes* F. and *P. cruciferae* Goeze. Only a few cases of damage to brassicae in gardens have been recorded.

THE MUSTARD BEETLE.—*Phaedon cochleariae* F.

Once recorded as injurious to brassicae in 1925. The beetles invaded an Aberystwyth market garden in thousands from an adjacent watercress bed, and caused very considerable damage.

Silpha opaca L.

Has been recorded once, the larvae causing slight damage to mangolds in Radnorshire.

THE MANGOLD FLEA BEETLE.—*Plectroscelis concinna* Marsh.

Often taken sparingly, this flea beetle has only been found in numbers in the Presteigne district, when considerable fenestration of the mangold leaves was caused, especially in 1925 and 1926.

WIREWORMS.—*Agriotes spp.*

Occasional slight damage to swedes by wireworms has been recorded.

THE CABBAGE ROOT FLY.—*Chortophila brassicae* Bch.

The cabbage root fly is a widely distributed pest, and often the cause of very considerable damage. It was considerably more prevalent in 1925 and 1926 than in the two previous years. Observations indicate that cauliflowers are particularly susceptible to attack. Charlock is a common host of this pest.

LEATHERJACKETS.—*Tipula spp.*

Leatherjackets have occasionally been recorded as injurious to brassicae, mainly in neglected gardens and allotments. One case of slight damage to field swedes was noted near Tenby.

THE MANGOLD FLY.—*Pegomyia betae* Curt.

The mangold fly is generally distributed throughout the area. In 1923 and 1924 little damage was done, but 1925 and, to a smaller degree, 1926 were characterised by widespread and heavy attacks, with practically complete failure of the crop in some cases, although most crops recovered remarkably well.

THE SWEDE MIDGE.—*Contarinia nasturtii.* Kieff.

A comparatively mild first brood attack by this midge, the cause of *Cabbage Top* or "*Buttoning*" of swedes and turnips in 1926, was followed by a second brood attack of much greater intensity, and particularly bad in the coastal districts of Merioneth and Cardigan. As a result of this second brood attack Crown Rot of swedes and turnips was very extensive.

CABBAGE WHITE BUTTERFLIES.—*Pieris spp.*

Larvae of the cabbage white butterflies were considerably more numerous in 1925 and 1926 than in previous years, those of *P. brassicae* L., the Large White, particularly so. Larvae of *P. rapae* L., the Small White, the most common species in previous years, showed a smaller increase. Larvae of *P. napi* L., the Green Veined White, are uncommon. Much damage was done to garden brassicae in 1925, the heaviest attacks observed being in Cardiganshire, Montgomeryshire and South Pembrokeshire. These caterpillars are responsible for little damage to field brassicae in the area.

THE CABBAGE MOTH.—*Barathra brassicae* L.

Not common in 1923, the larvae of the cabbage moth were very abundant in 1924 and 1925 and were easily the most injurious of the cabbage caterpillars in many districts.

THE DIAMOND BACK MOTH.—*Plutella maculipennis* Curt.

Larvae of this moth were extremely abundant in 1923 and in many districts, notably in North Pembroke, Brecon and Radnor generally, and Carmarthen, in the Llanddowror district, and in many cases caused very considerable loss. The worst case noted was 75% loss on thirty acres of mixed rape and swedes near Fishguard. In 1924 and 1925 little damage was caused.

THE GARDEN CARPET MOTH.—*Xanthorrhoe fluctuata* L.

Slight damage by the larvae of this moth to field cabbage has been once recorded near Aberystwyth.

THE GARDEN PEBBLE MOTH.—*Pionea forficalis* L.

The larvae of this moth were extremely abundant in several districts in Cardigan in 1924, in many cases being quite a serious pest of garden brassicae. They were slightly less common in 1925 and 1926.

THE SILVER Y MOTH.—*Plusia gamma* L.

The larvae were very common in the late summer and early autumn of 1924, and did considerable damage to garden brassicae. They were less abundant in the other two years.

THE TURNIP MOTH.—*Agrotis segetum* Schiff.

THE HEART AND DART MOTH.—*Agrotis exclamationis* L.

The larvae of these moths do not appear to be common pests. Nearly all the damage recorded has been to garden brassicae, and has never been extensive, except to swedes near Towyn in 1926 and near Tregaron in 1924.

THE BRIGHT LINE BROWN EYE MOTH.—*Hadena oleracea* L.

The larvae of this moth have once been recorded in small numbers on allotment cabbages.

THE MEALY CABBAGE APHID.—*Brevicoryne brassicae* (L).

This aphis is a fairly common pest of brassicae in the area. Several severe attacks have been recorded, particularly on young broccoli, when blindness usually followed the attack.

SPRINGTAILS.—*Collembola.*

Springtails have occasionally been recorded as injurious to young turnips and swedes. The species concerned was not identified.

SLUGS.

Caused considerable damage generally in 1923, but in 1924 were exceedingly numerous and were easily the worst pest of the season. In one garden of about three acres 82,300 slugs were trapped between January and July. *Agriolimax agrestis* L. is the most common species and is closely followed in some districts by *Arion hortensis* Fer.

MILLIPEDES.

See pests of other vegetables.

Pests of Other Vegetables.

GENERAL.

WIREWORMS.—*Agriotes spp.*

Wireworms are a common cause of damage to many vegetables. Attacks are more frequent in allotments than in gardens, particularly where the former have been recently brought into cultivation.

LEATHERJACKETS.—*Tipula spp.*

Leatherjackets are frequently complained of as destructive to various garden crops.

SLUGS.

These pests, although causing considerable damage in most seasons, were enormously injurious and destructive in 1924. Whilst practically all garden crops suffered some injury, the following (apart from brassicae and potatoes) were found to be most often attacked :—Peas, broad beans, runner beans, celery, leeks, lettuce, rhubarb. *Agriolimax agrestis* L. is the most abundant and most injurious species, with *Arion hortensis* Fer. common in some districts. One case of severe damage to lettuce by *Milax gagates* Drap. has been recorded at Aberystwyth.

MILLIPEDES.

Blanjulus pulchellus Leach and *Julus terrestris* L. have on several occasions been recorded as injurious to vegetables, some of the more serious attacks occurring on onions and shallots near Talgarth, Knighton, and Lampeter and district; on celery at Lampeter, and on cucumbers and marrows at Carmarthen. *Polydesmus complanatus* L. was the cause of a very heavy attack on all vegetables near Bala in 1926.

PEAS.

PEA AND BEAN WEEVILS.—*Sitones lineatus* Linn.

A few instances of slight damage to garden peas were recorded in 1923 and 1924. The weevil was much more common in 1925 and 1926, when several cases of more or less severe damage, particularly to young peas, were observed.

THE PEA LEAF MINER.—*Phytomyza pisi.* Kalt.

The pea leaf miner is not uncommon but has never been found in numbers.

THE PEA THRIPS.—*Kakothrips robusta.* Uzel.

Is not common in the area, and no cases of damage have been recorded.

BROAD BEANS.

PEA AND BEAN WEEVILS.—*Sitones lineatus* Linn.

Damage to foliage was common, and sometimes severe, in 1925. One case of severe root damage by the larvae was recorded from Carmarthen. The weevil was less injurious in 1923 and 1924.

THE BLACK BEAN APHIS.—*Aphis rumicis* L.

Very uncommon in 1923 and 1924; the worst attack for years occurred in 1925. Attacks were general throughout the area, and infestations very heavy. It was less common in 1926.

COCKROACHES.—*Orthoptera.*

Cockroaches have once been recorded as destructive to young broad beans near Lampeter.

FRENCH AND RUNNER BEANS.

THE BLACK BEAN APHIS.—*Aphis rumicis* L.

Has occasionally been recorded on runner beans.

THE CINNABAR MOTH.—*Hipocrita jacobaeae* L.

The larvae, whose normal food is groundsel, have once been recorded on runner beans at Aberystwyth.

TOMATO WHITEFLY.—*Aleurodes vaporariorum* Westw.

A severe attack on young plants under glass has been recorded near Aberystwyth.

FROGHOPPERS.—*Cercopidae.*

Severe attacks occurred in Pembrokeshire in 1925 with prevention of pod formation.

CARROTS.

THE CARROT FLY.—*Psila rosae* Fab.

The carrot fly is very generally distributed throughout the area; carrot growing in some districts has been practically abandoned owing to its ravages. It was more common in 1923 than in 1924, when most of the damage was caused by a late second brood. It was very common in 1925, but attacks were on the whole slightly lighter than usual. In 1926, although commonly occurring, attacks were light.

THE CARROT APHID.—*Anuraphis dauci* (F).

One record of slight damage by this aphid has been made near Aberystwyth.

PARSNIPS.

THE CARROT FLY.—*Psila rosae* Fab.

Occasional attacks on parsnips have been noted. Damage was severe in one case only, near Newcastle Emlyn.

THE CELERY FLY.—*Acidia heraclei* Linn.

Slight attacks have been recorded from time to time.

BEETROOT.

THE MANGOLD FLY.—*Pegomyia betae* Curt.

A common pest of beetroot in 1925, when many severe attacks were recorded. It was less abundant in 1923 and 1924.

EELWORM.—*Heterodera schachtii* Schmidt.

Has only once been recorded on beetroot at Aberystwyth. Since the crop was also attacked by the fungus *Phoma betae* Frank, the extent of damage by *H. schachtii* could not be estimated.

PARSLEY.

THE CARROT FLY.—*Psila rosae* Fab.

Attacks of varying intensity have been frequently recorded, including cases of total failure of the crop near Dolgelley, Somerton and Aberystwyth.

ONIONS, LEEKS AND SHALLOTS.

THE ONION FLY.—*Phorbia cepetorum* Meade.

Stated to be a serious pest in some years in several localities, the onion fly appears to have been decidedly below normal in the period under review, although many cases of moderate attack have been recorded.

THE HEART AND DART MOTH.—*Agrotis exclamationis* L.

The larvae have once been recorded as destructive to leeks at Lampeter.

CELERY.

THE CELERY FLY.—*Acidia heraclei* Linn.

Widely distributed throughout the area, and very destructive in some seasons, the celery fly was below normal in the period under review. Fairly common in 1923 and 1925, it was scarce in 1924 and 1926.

MARROW AND CUCUMBER.

Aphis gossypi Glov.

Has been frequently recorded, particularly on seedlings under glass.

Myzus pelargonii (Kalt).

Once recorded on marrow seedlings under glass.

THE TOMATO WHITE FLY.—*Aleurodes vaporariorum* Westw.

See under tomatoes.

THRIPS.—*Thysanoptera.*

Slight attacks on cucumbers occasionally met with. The species was not identified.

WOODLICE.—*Oniscidae.*

Woodlice have been frequently recorded as very destructive to cucumbers.

RED SPIDER.—*Tetranychus telarius* Linn.

Not a common pest of cucumbers, but has been recorded near Devil's Bridge, Haverfordwest and Aberystwyth.

ROOT KNOT.—*Heterodera radicicola* Greef.

This eelworm does not appear to be a common pest of cucumbers, having been recorded on a few occasions only.

TOMATOES.

TOMATO WHITE FLY.—*Aleurodes vaporariorum* Westw.

Practically a universal pest of tomatoes, cucumbers, marrows and many other glasshouse plants. Growers report increasing

control, which appears to be due to a more general use of various commercial preparations containing tetrachlorethane, and, more recently, of calcium cyanide.

Mushrooms.

Sciara praecox. Mg.

The larvae of this fly are not uncommon parasites of mushrooms growing in the open.

Woodlice.—*Oniscidae.*

Woodlice are not infrequently complained of as destructive to mushrooms cultivated under cover.

Pests of Fruit Trees.

Apple.

Apple Blossom Weevil.—*Anthonomus pomorum* Linn.

Widely distributed in the area, the apple blossom weevil was slightly more common in 1923 than in the three subsequent years. No severe attacks have been recorded, the highest being 10%—15%.

Leaf Weevils.—*Phyllobius pyri* L., *Phyllobius argentatus* L.

These two weevils were very common in 1924, and were in many localities, such as parts of the Aeron Valley and Newbridge district, the most destructive of the foliage pests of apples and pears. They were slightly less common in 1925 and 1926.

The Raspberry Weevil.—*Otiorrhynchus picipes* F.

Occasionally taken on apple and pear, this weevil is neither common nor abundant.

The Winter Moth.—*Cheimatobia brumata* Linn.

The most common of the "winter moth" caterpillars, this was fairly destructive in 1923, particularly in parts of Carmarthenshire. In 1924 it was far less common, but in 1925 and 1926 widespread and often serious damage was caused, particularly in Brecon, Radnor, Mid Cardigan, Carmarthen and East Montgomery. One case of a high degree of parasitism by eelworms (*Mermithidae*) has been recorded from Devil's Bridge district.

The Mottled Umber Moth.—*Hybernia defoliaria* Cl.

Not a widely distributed pest. The larvae have only once been recorded in any number in North Cardigan in 1925.

The March Moth.—*Anisopteryx aescularia* Schiff.

Not a common pest.

THE VAPOURER MOTH.—*Orgyia antiqua* L.

Has only been met with occasionally.

THE LITTLE ERMINE MOTH.—*Hyponomeuta padella* Linn.

Not a common pest; has been recorded in small numbers in North Cardigan.

CASE BEARING MOTHS.—*Coleophora sp.*

The larvae have occasionally been met with, but material damage has not been recorded.

THE APPLE LEAF MINING MOTH.—*Lyonetia clerkella* L.

This leaf miner is fairly generally distributed and appears to be commoner in the coastal districts. No attacks of economic importance have been recorded.

THE BRIMSTONE MOTH.—*Opisthograptis luteolata* L.

The larvae of this moth have once been recorded on apple in North Cardigan. The damage was slight.

THE CODLIN MOTH.—*Cydia pomonella* L.

The codlin moth was uncommon in 1923 and 1924, the only case of material damage being recorded being an interesting second brood attack causing 50% damage in Montgomeryshire in the latter year, and again in 1926. In 1925 the moth was much more prevalent. Slight attacks were general, with more serious ones locally, notably in the Crickhowell district.

TORTRIX MOTHS.—*Tortricidae.*

Tortrix moth larvae are common throughout the area. They were more plentiful in 1925 than in the previous two years, but no severe damage has been recorded. The species taken are *Tortrix ribeana* Hb., *T. rosana* Linn. and *T. heparana* Schiff.

THE EYED HAWK MOTH.—*Smerinthus ocellatus* L.

A severe outbreak occurred in a small orchard near Carmarthen in 1926, when many young standards were defoliated by the larvae.

THE COMMON QUAKER MOTH.—*Taeniocampa stabilis* View.

THE ENGRAILED MOTH.—*Tephrosia bistortata* Goeze.

THE SCALLOPED OAK MOTH.—*Crocallis elinguaria* L.

The larvae of these moths were extremely abundant in the spring of 1926 in an orchard near Devil's Bridge, and far outnumbered the usual "apple caterpillars." They have not been taken elsewhere on apple.

THE ROSY APPLE APHID.—*Anuraphis roseus* Baker.

Widely distributed throughout the area and fairly common in 1925, it was less common in 1924, when no large colonies were observed. In 1925 it was very much more common, and considerable damage was reported and recorded in many districts, notably in Montgomery, Carmarthen, Brecon and Radnor. Eggs in the winter of 1925 were considerably more numerous than in former years, and an exceedingly heavy attack followed in 1926.

THE GREEN APPLE APHIS.—*Aphis pomi* De Geer.

Not a common pest in 1923 or 1924, the green apple aphis was far more common and more numerous in 1925 and 1926. It is, however, by no means as common or as injurious as *A. roseus*.

THE APPLE SUCKER.—*Psylla mali.* Schmdbg.

Fairly common distributed in small numbers in 1923, the apple *Psylla* could usually be found by searching in 1924, but the numbers were very small. In 1925 and 1926 it was very much more common and considerable damage was done to the blossom trusses of early varieties in particular in many districts.

THE WOOLLY APHIS.—*Eriosoma lanigera.* Hausm.

The woolly aphis is almost of universal occurrence and often most injurious. An attempt has been made to introduce *Aphelinus mali*, a chalcid parasite of the woolly aphis, into the area. The attempt has had an initial success in that over-wintering "coccoons" have established themselves. Whether they occur in numbers sufficiently strong to permit the parasite to make headway remains to be seen. The aphis was particularly abundant in 1926.

THE APPLE SCALE.—*Lepidosophes ulmi.* Linn.

A very widely distributed scale, almost always to be found on older trees in particular. Severe damage does not appear to be common, although one case of the killing off of a young standard has been recorded. It has rarely been found on the fruit.

CAPSID BUGS.—*Psallus ambiguus* Fall., *Phytocoris tiliae* Fab., *Phytocoris reuteri* Saund., *Aetorhinus angulatus* Fab.

These capsid bugs have occasionally been sparingly taken on apples.

THRIPS.—*Thysanoptera.*

A species of thrips, which was not identified, was responsible for considerable damage to the blossom trusses of late flowering

varieties in several districts in Cardiganshire in 1928. It occurred in every year, but the damage was slight.

Orchesella cincta.

This collembolan was found causing slight damage to apple foliage in one orchard in 1924.

PEAR.

THE APPLE BLOSSOM WEEVIL.—*Anthonomus pomorum* Linn.

The apple blossom weevil has on several occasions been recorded on pear blossom, the heaviest attack being 20% near Goginan.

Phyllobius pyri L., *Phyllobius argentatus* L.

See apple pests.

Otiorrhynchus picipes F.

See apple pests.

THE PEAR MIDGE.—*Diplosis pyrivora* Riley.

The pear midge was not a common pest in 1923 and 1924, and its distribution was very local. It was far more common and more injurious in 1925, one 50% attack on variety Jagonelle being recorded, whilst lighter attacks were complained of in many localities.

THE WINTER MOTH.—*Cheimatobia brumata* Linn.

The larvae of the winter moth are very frequently recorded on pears, but no cases of serious damage have been observed.

TORTRIX MOTHS.—*Tortricidae.*

Tortrix larvae frequently attack pears, but no extensive damage has been recorded.

THRIPS.—*Thysanoptera.*

Slight damage to pear blossom by an unidentified species of thrips has been observed occasionally.

THE PEAR SUCKER.—*Psylla pyricola* Först.

Does not appear to be a commonly occurring species, and has been found in numbers in one locality only—Mid Cardigan—in 1925 and 1926.

THE PEAR LEAF BLISTER MITE.—*Eriophyes pyri.* Pagst.

A common and widespread pest of pears which appears to be on the increase. Trees growing against walls appear to be most severely attacked. A case of severe damage to fruitlets has been recorded from the Aeron Valley.

Cherry.

Cheimatobia brumata Linn., *Tortricidae*.

The larvae of these moths occur from time to time on cherries, but no cases of severe damage have been recorded.

Black Cherry Aphis.—*Myzus cerasi* F.

The black cherry aphis, although widely distributed throughout the area, was very scarce during 1923 and 1924, heavy attacks being very local and almost entirely in Carmarthenshire. In 1925 the aphid was very common and the attacks unusually heavy, Carmarthenshire again being the chief sufferer. It was less common in 1926.

The Apple Leaf Miner.—*Lyonetia clerkella* L.

Cherries from time to time suffer from slight attacks by this moth.

Plum and Damson.

Leaf Curling Plum Aphis.—*Anuraphis prunina* Walk.

The leaf curling plum aphis was very abundant and widely distributed in 1923, 1925 and 1926, and caused much severe shoot distortion. Districts which suffered particularly were South Pembrokeshire, Carmarthenshire and South Breconshire. In 1924, although of wide occurrence, the colonies were small, the only severe attack noted being upon a wild plum.

Mealy Plum Aphis.—*Hyalopterus arundinis* (F).

Not so commonly distributed nor so abundant as *A. prunina*, this pest was fairly widespread in 1923. In 1924 it was uncommon, but in 1925 frequent complaints of heavy attacks were received. It was less common in 1926.

Plum Leaf Gall Mite.—*Eriophyes similis* Nalepa.

Not a common pest of plums. A few heavy infestations were recorded in 1925 in the Aberystwyth districts.

Strawberry.

The Winter Moth.—*Cheimatobia brumata* Linn.

Winter moth larvae have once been observed on strawberries. Damage was slight.

The Strawberry Aphid.—*Capitophorus fragariae*. Theob.

Not an abundant strawberry pest; one case of severe damage only has been recorded.

The Strawberry Eelworm.—*Aphelenchus fragariae* Ritzema Bos.

Does not appear to be very commonly distributed and no heavy attacks have been recorded.

CURRANTS AND GOOSEBERRIES.

THE COCKCHAFER.—*Melolontha vulgaris* Fab.

The larvae have been recorded near Lampeter and near Towyn from the roots of black currants. There was no apparent ill effect on the bushes.

THE CURRANT CLEARWING MOTH.—*Aegeria tipuliformis* Cl.

Not a common pest of the area, having been recorded in one locality in Cardiganshire only.

THE MAGPIE MOTH.—*Abraxas grossulariata* L.

Not a common pest during the years under review, when from growers' reports it appears to have been below normal. It was more abundant in 1925 and 1926 than in the two previous years, and complaints of fairly considerable damage were received from the Glazebury and Crickhowell districts.

THE V MOTH.—*Thamnonoma wavaria* L.

The larvae of this moth were found defoliating red and black currant bushes in two orchards near Aberystwyth in 1926.

THE GOOSEBERRY SAWFLY.—*Nematus ribesii* Scop.

A very widely distributed pest of gooseberries and red currants, and sometimes found attacking black currants. In 1923 and 1924, although cases of more or less serious defoliation occurred, the pest was not abundant. In 1925 it was widespread and very abundant. South Breconshire appeared to be the worst sufferer, in some districts practically every gooseberry bush being defoliated. It was slightly less abundant in 1926.

GREENFLIES.—*Aphis grossulariae* Kalt.

Very widely distributed and the cause of much gooseberry shoot distortion in 1923. Although of general occurrence, colonies were small in 1924, and little damage was caused. In 1925 the aphis was again very abundant. *Amphorophora lactucae* Kalt. Fairly widely distributed, this aphid was fairly abundant in 1923, and less so in 1924. In 1925 it was very common and many heavy infestations were recorded, notably in South Breconshire and Carmarthenshire. More common on currants than on gooseberries. *Capitophorus ribis* L. Fairly generally distributed, this aphid has never been found in abundance, and, contrary to expectation, it appeared to be slightly less common in 1925 than in the two previous years. It was much more abundant in 1926. *Rophalosiphoninus ribesina* V. de G. A heavy attack by this aphid, on red currants, occurred in 1926 at Llanfarian. This constitutes the first record of the species in Great Britain.

GOOSEBERRY RED SPIDER.—*Bryobia nobilis* Th.

Does not appear to be a common pest of the area. Stated to have been abundant on gooseberries in South Brecon in 1921, a few complaints of slight attack have been received from that area during the years under consideration.

BIG BUD OF BLACK CURRANTS.—*Eriophyes ribis* Nal.

A very common and widely distributed pest of black currants. No attack on red currants has been recorded.

LOGANBERRY.

Priophorus tristis Zadd.

One case of attack by this sawfly has been recorded near Aberystwyth. It resulted in about 30% defoliation of a single plant. The record is of interest as the sawfly appears to have a limited distribution in Britain.

PEACH, APRICOT, MEDLAR.

TORTRIX MOTHS.—*Tortricidae.*

Tortrix larvae have occasionally been met with on peaches and medlar. In the latter instance the unopened blossom only was attacked.

THE PEACH SCALE.—*Lecanium persicae* Fab.

Of frequent occurrence on peaches on both indoor trees and outdoor trees in sheltered situations. Has never been recorded in abundance.

Lecanium hesperidum Linn.

Once recorded on peach trees under glass near Llanilar. The attack was heavy and caused general unhealthiness.

MEALY BUG.—*Dactylopius citri.* Risso.

Attacks on peaches have been recorded from time to time, usually very slight.

THRIPS.—*Thysanoptera.*

Slight damage to peach blossom by an unidentified species occurred in Cardiganshire in 1923 and 1924. Another species, also unidentified, caused fairly severe leaf curl to apricots near Penybont, Radnorshire.

VINE.

THE VINE SCALE.—*Pulvinaria vitis* Linn.

Recorded once only, in Cardiganshire, a light attack.

THE WOOLLY APHIS.—*Eriosoma lanigera* Hausm.

Has once been recorded in small numbers.

RED SPIDER.—*Tetranychus telarius* Linn.

Does not appear to be a common pest, slight infestations only having been recorded.

GENERAL.

WASPS.—*Vespa spp.*

Fairly common in 1923, wasps were most uncommon in 1924. In 1925 and 1926 they were very abundant, in some districts exceedingly so, compelling fruit pickers to wear gloves and veils, and did considerable damage, particularly to plums. The most common species is *V. vulgaris* Linn., closely followed by *V. germanica* Fab., whilst in some districts *V. sylvestris* Scop. is almost equally common.

Pests of Stored Products.

THE GRANARY WEEVIL.—*Calandra granaria* Ol.

Damage by this pest has been once recorded, from Castlemartin. The attack was serious, over 50% of the grain being destroyed.

Ptinus tectus Boield.

One case of severe damage by this beetle has been recorded to linseed cake.

Niptus hololeucus Fald.

Although taken on several occasions from various foodstuffs, this beetle has never been found to cause material damage.

Endrosis lactella S.D.

The larvae of this moth were present in some numbers on stored clover seed at Aberystwyth in 1924, but did not appear to cause much damage.

THE MEDITERRANEAN FLOUR MOTH.—*Ephestia kuehniella* Z.

A very heavy infestation of dog biscuits in store at Aberystwyth occurred in 1926.

Aleurobius farinae Scop., *Glycyphagus sp.*

These two mites were associated in the destruction of stored wheat at Aberystwyth, causing considerable damage. The first named species was the more numerous.

Pests of Flowers and Trees.

No special effort has been made to record these pests, and, therefore, what follows is not a survey of them, but a list of those that have been brought to the writer's notice or that he has happened to observe.

WEEVILS.

The pine weevil, *Hylobius abietis* Fab., is known to have caused much damage to young pines near Lampeter and near Llandilo.

GREENFLIES.

Anuraphis chrysanthemi Walk., common on chrysanthemums and particularly abundant in 1926; *Aphis lantanaella* Theob., a heavy infestation of guelder roses at Llangeitho, causing the death of the trees; *Capitophorus tetrarhodus* Walk., not uncommon on roses, especially under glass; *Drepanosiphum platanoides*, a common sycamore aphid, often occurring in enormous numbers; *Liosomaphis berberidis* Kalt., on the common barberry; *Macrosiphoniella sanborni* Gill., common on chrysanthemums, especially in 1926; *Macrosphum pisi* Kalt., occasionally taken on sweet peas; *Macrosiphum rosae* L. and *M. solanifolii* Ashm., common rose aphides; *Myzocallis coryli* Goetz., occasionally abundant on hazel; *Myzus circumflexus* (Buckt.), common in many greenhouses, especially on arum lilies; *Pterochlorus viminalis* B. de Fon., on willows; and *Myzus polyanthi* Theob. on primulas.

SCALE INSECTS.

Pulvinaria floccifera Westw. has been frequently noted on various hothouse plants, and *Lecanium hemisphaericum* Targ.-Tozz. is not uncommon on adiantum under glass.

MEALY BUG.—*Dactylopius citri* Risso.

Has been recorded on oranges and dendrobes.

Chermes piceae Rtzb.

Heavy attacks have been recorded on firs at Llandderfel and Haverfordwest.

Psylla buxi Linn.

A widespread pest of box, causing " cabbage head."

HOP RED SPIDER.—*Tetranychus altheae* Von Haus.

Once recorded from Tenby.

TULIP MITE.—*Rhizoglyphus echinopus* F. and R.

Recorded on tulips at Aberystwyth.

PRELIMINARY STUDIES ON THE ABSENCE OF YELLOW COLOUR IN FATUOID OR FALSE WILD OATS.

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Introductory and Historical.

The observation that a relationship exists between the development of yellow colour and the degree of awning in the grain of certain varieties of oats was first recorded by Nilsson-Ehle (10). In studies with a large number of line selections from single non-selected plants of the old Probsteier oat he observed that the progeny of the yellow-grained plants were more feebly awned than those of the white. Of the latter, some lines were awnless and others showed different degrees of awning from 0 to nearly 100 per cent. Among the yellow lines there existed only awnless and weakly-awned types.

In addition to the above he observed that in the yellow-grained awnless Probsteier oat

> " there emerge occasionally isolated white individuals
> " (undoubtedly on account of spontaneous omission
> " [*Wegfallen*] of the yellow factor); these white individuals
> " are, exactly as is to be expected, often awned : one always
> " searches in vain for awned yellow individuals ".[1]

In a cross between a black awned (average of about 54 per cent. awns) and a yellow awnless (a selection from Probsteier) Nilsson-Ehle obtained complete correlation between yellow colour and weak awning in the F_2 segregates. Confirmation of this was provided in a portion of the F_2 plants which were carried on to the F_3 generation. The F_2 segregation for colour of grain in this cross gave blacks, yellows and whites, in the approximate ratios of twelve black : three yellow or yellowish : one white. Most of the whites and several of the blacks were strongly awned, but the yellows were either awnless or only weakly awned. The reason why the white F_2 plants were, on the average, the most strongly awned he ascribed as being due to the absence of yellow. In the black-grained segregates, however, yellow is present hypostatically in a certain proportion, and in these, consequently, there is reduced awn development. The degree of awning was found to show slight fluctuations from year to year due to seasonal and environmental effects, but in all individuals which contained the yellow factor in the homozygous condition the awning was

[1] Literal translation from text.

strongly suppressed. In the heterozygous form the suppression, although not so strong, was still clearly present. In explanation of these phenomena it was suggested that the yellow factor produces not only yellow colour, but also at the same time acts as an inhibitor of the development of awns.

Of the non-black F_2 segregates those heterozygous for yellow were described as being yellowish in colour, although in somewhat unequal degree. In order to separate these from the homozygous whites it was necessary to study their breeding behaviour in the F_3 generation.

Since the publication of these results by Nilsson-Ehle, the study of the inhibitory effects of the factor for yellow colour has received increased attention. Such investigations are of practical importance in view of the fact that a high percentage of awns is not conducive to good quality grain, as judged by the percentage husk. A high degree of awning also detracts from the commercial value of the grain. Owing, however, to the seasonal and environmental fluctuations exhibited by the normal awn typical of the cultivated varieties of oats, and the stable and constant behaviour of the *Avena fatua* and fatuoid types of awn, the latter appear to be helpful material for the further investigation of this problem. It should, however, be pointed out that the awn of *Avena fatua*, and of the false wild or fatuoid types, exhibits practically complete linkage with the horse-shoe shaped base, and pubescent callus and rachilla which characterize the *fatua* or fatuoid types of grain.[2] In such material, therefore, the study of the relationships between the yellow colour of the grain and awn development necessarily involves the other linked characters, and resolves itself into an investigation of the *fatua* or fatuoid complex in relation to the colour of the grain.

In hybridization experiments with *Avena fatua* L., and *Avena sativa* L., var. Kherson, Surface (13) found that the cultivated or *sativa* type of base was dominant to the wild or *fatua* type, and that no association existed between the *fatua* grain characters and the factors involved in the production of the colour of the grain. In the F_2 generation he was able to distinguish three main classes in regard to colour, namely, black, grey and yellow. In the third class some of the plants, however, were almost white. The figures obtained showed good agreement with a 12 : 3 : 1 ratio for black, grey and yellow respectively, and in the subsequent discussion and data the whitish plants were included in the yellow class and the two factor hypothesis adopted as being the most

[2] For descriptions of *Avena fatua* and fatuoid types of grain and their breeding behaviour see recent reviews of literature by Huskin and Fryer (6), also Stanton, Coffman and Wiebe (11).

plausible interpretation of the results. The *fatua* parent was assumed to carry the factors for grey and probably for yellow colour in addition to the black, whereas the Kherson parent carried the factor for yellow only; segregation was thus confined to the factors for black and grey—yellow being homozygous in both parents. Whilst no difficulty was experienced in classifying the blacks as opposed to the non-blacks, the several shades of grey and yellow made it difficult to determine whether these should be classified as grey, yellow or white.

Love and Craig (7) also investigated crosses between *Avena fatua* and *Avena sativa*, var. Sixty Day (this variety is stated to be identical, morphologically, with the Kherson used by Surface), in which black, grey and yellow segregates were obtained in ratios closely agreeing with those obtained by Surface. They also observed that the grains of some of the segregates were almost white in colour, but on further test these appeared to be greys. They, however, found a definite negative correlation to exist between the wild or *fatua* base and the yellow colour of the grain, and no yellow *fatua* segregates appeared in the whole of their F_3 and F_4 material. The absence of the yellow *fatua* type was attributed to the inhibitory effect of the yellow colour, but no detailed interpretation was given. The pale greys and yellows were found to be difficult to classify. In the F_2 generation the blacks in relation to non-blacks gave a fairly close agreement with a 3 : 1 ratio, but amongst the non-blacks there were too few yellows and too many greys. The grouped figures for three third generation families showed rather better agreement in this respect. Segregation for type of grain gave approximately three *sativa* types to one *fatua* type.

In addition to the absence of the yellow *fatua* type, there was also an absence of yellow pubescent segregates. The non-appearance of these was explained by assuming that yellow inhibited the production of pubescence in the absence of the factors for black and grey.

Tschermak (15) in crosses between *Avena fatua* and cultivated oats obtained yellow-grained types possessing the basal articulation and awn characteristic of the *fatua* parent. No linkage between colour and type of grain was observed, and no inhibition between yellow and the *fatua* form of grain.

Love and Fraser (8) and Fraser (4) in crosses between Burt (*Avena sterilis*) and Sixty Day, the former awned and the latter practically awnless, explained the partial dominance of the awnless condition in Sixty Day over the weak-awned Burt as being due to the presence of an inhibitory factor. Both parents were regarded

as possessing factors for awning, but in Sixty Day awn development is suppressed by the presence of the inhibitory factor. Linkage is stated to exist between the inhibitory factor and the factor for yellow colour in the variety Sixty Day. Love and Fraser also state that " a very definite linkage of the inhibitory " factor with the factor for yellow colour has already been " observed in a cross between *Avena fatua* and *Avena sativa*, var. " Sixty Day." Burt, however, was found to possess a factor for yellow which does not inhibit awning, owing to the presence of which the inhibitory effects of the yellow of the Sixty Day could not easily be followed.

Coffman, Parker and Quisenberry (1) in a study of variability in the Burt oat found that the colour of the grain was not properly developed until the kernel was fully mature, and that any condition causing interference with normal ripening made the task of accurate colour classification an extremely difficult one, especially in regard to the yellow and white-grained types. In the 1921 data, few of the yellows were found to breed true; the " kernels classified as white appear to be of two classes, those " which for physiological reasons did not fully develop their " normal colour and thus appeared white, although genetically " really coloured, and those which were genetically white ". They also report that a certain degree of association exists between colour of grain and non-twisted awns, but little, if any, between colour of grain and twisted awns. The yellow and white grains were, however, more frequently awnless than the red, brown or black.

These writers quoted studies made by Wilds (16) of a cross between *Avena fatua* and Tartar King (white), which in F_2 segregated into approximately twelve blacks : three greys : one white; also a cross between *Avena fatua* X Sixty Day (yellow), which gave a segregation of twelve blacks : three greys : one yellow. Wilds (16) they state, obtained a negative correlation between yellow colour of grain and each of the following characters : *fatua* type of articulation, awns, basal pubescence and dorsal pubescence of the grain.

Coffman and Stanton (2) in a study of variability in the Kherson oat found yellow to be the most stable colour in its breeding behaviour, whereas some of the reddish yellows and whites frequently gave progenies consisting of varying proportions of reddish-yellows, yellows and whites.

They found that in Kherson there exist only two factors for colour, a yellow and a white, and that physiological influences are the apparent cause of genotypically yellow grain appearing and

being classed as phenotypically white, and *vice versa*. In regard to awn development in relation to the yellow colour of grain, no evidence was obtained which indicated either linkage between the awnless condition and yellow colour, or inhibitory effects of yellow colour upon the production of awns. They also consider that "the results of Love and Fraser (8), Love and Craig (7) and "Fraser (4) all fail to show conclusively that the Kherson or "Sixty Day oats contain an inhibitor for awns linked with the "yellow colour".

Crepin (3) in separations of the progeny of a presumed natural cross between Golden Rain and *Avena fatua* obtained yellow *fatua* types. The subsequent breeding behaviour of these has not yet been reported upon.

Garber (5) also reports having found two fatuoid plants in the variety Aurora which agreed with the normal type in being yellow in the colour of the grain.

Similar yellow-grained fatuoids of the variety Aurora have also been recorded by Stanton, Coffman and Wiebe (14).

No data is available, however, as to whether these colour determinations were made on partly matured, or on well dried and fully matured specimens.

Experimental.

The False Wild or Fatuoid Parent.

In a plot of Golden Rain oats (*Avena sativa* L.) a single fatuoid plant was observed which, in addition to the false wild characters, differed also from the normal variety in the absence of the bright yellow colour of grain characteristic of Golden Rain. The grain of this fatuoid form was white, with traces of a slight pale brown coloration in the basal portion of the outer palea. During early studies with this plant and some of its progeny considerable doubt existed as to whether this fatuoid type represented a definite fatuoid of Golden Rain or whether it was a stray fatuoid plant of a white oat variety. Recent observations, however, have shown that amongst subsequent selfed generations of this material occasional plants are to be found which on close examination show traces of yellow colour in just a few grains of the panicle. This development of traces of colour is by no means general and appears only in occasional grains of a very few plants. Most of the plants show no indication whatsoever of yellow colour.

The Golden Rain Parent.

According to Newman (12) this variety is a pure line selection produced at Svalöf from the old Probsteier oat. The grain of

this variety is described by Marquand (9) as being awnless, completely glabrous and of a bright yellow colour. That of the selected parent used in these studies agreed with this description.

The F_1 Generation.

In order to study the behaviour of yellow in relation to the fatuoid character, crosses were made in 1923 between pure line descendants of the fatuoid plant and the variety Golden Rain. Five seeds were obtained, which in 1924 produced five hybrid plants. All were of uniform type and all showed the usual degree of dominance of the *sativa* over the fatuoid type of grain such as is generally found in crosses involving these two characters. In regard to colour, however, there was an almost complete absence of yellow, the grain in this respect closely resembling that of the fatuoid parent.

Segregation in the F_2 Generation.

In the F_2 generation there was a similar absence of colour in those segregates which contained the fatuoid character in the homozygous or heterozygous condition, with the exception of the appearance of slight traces of yellow in occasional grains of just a few plants.

From the nature of the segregation it seems fairly clear that the fatuoid parent must be genotypically yellow—otherwise a certain proportion of the homozygous non-fatuoid segregates would be white in colour; all these were yellow, as will be seen from an examination of Table I below.

TABLE I.

F_2 segregation of the fatuoid and *sativa* characters in relation to the colour of the grain.

	Grain Yellow as in Golden Rain.			*Grain showing absence of Yellow as in the Fatuoid Parent.*		
NATURE OF CROSS.	*Fatuoid type grain.*	*Inter. type of grain.*	*Sativa. type of grain.*	*Fatuoid*	*Intermediate.*	*Sativa.*
Fatuoid X Golden Rain	—	—	12	9	26	—
Golden Rain X Fatuoid	—	—	9	16	18	—
TOTALS	—	—	21	25	44	—
"Expected" on a monohybrid basis with no segregation for colour of grain*	—	—	22.5	22.5	45.0	—

* Monohybrid segregation for fatuoid and *sativa* characters is in agreement with results obtained by Nilsson-Ehle (11) and various other investigators.

In the F_2 generation only the parental and F_1 types were obtained, viz. :—yellow *sativa*, non-yellow fatuoid and non-yellow intermediates. The segregation is mono-factorial and related to

the allelomorphs fatuoid and non-fatuoid or *sativa* which affect only the type of grain. There is no independent segregation for colour, and the yellow colour is fully expressed only in the absence of the fatuoid character. Assuming the fatuoid parent to be homozygous for yellow but with the development of the yellow colour interfered with or suppressed by the fatuoid character or some factor or factors associated with it, then crossing with Golden Rain should give in the F_2 generation a segregation closely similar to that actually obtained, namely, twenty-one yellow *sativa*, forty-four non-yellow intermediates, and twenty-five non-yellow fatuoids (the theoretical expectation being 22.5 : 45.0 : 22.5).

In the classification of the plants of the F_2 generation segregating for the fatuoid and *sativa* characters, the identification of the homozygous fatuoid genotypes is a simple matter. Distinction between the intermediate and *sativa* phenotypes, however, is less pronounced and less defined and necessitates close examination. In this particular material the appearance of yellow in all the *sativa* types and its almost complete absence in those possessing the intermediate characters facilitated the separation of these two classes. The intermediates, however, showed a range in degree of awning from plants with all lower grains awned to those with only relatively few lower grains awned.

The F_3 Generation.

In order to make certain that none of the intermediates with poor awns were not of the constitution white *sativa*, and in order to verify the sub-division of non-fatuoids into intermediates and normals, F_3 families were grown in 1926 from all of the non-fatuoid segregates of one complete F_2 family. Seeds from each of these F_2 plants were sown in separate drills representing plant rows. Owing to inclement weather conditions during the early spring and to insect depredations the seedlings from two of the F_2 intermediate plants died off before reaching the heading stage; all the other sowings, however, produced good plants.

During an examination of these F_3 families, just preceding the time of harvest, it was seen that all of the progeny of those classified in F_2 as intermediate showed segregation, whilst all of those classified as yellow *sativa* bred true for these two characters. The classification made in F_2, with the exception of the two families which failed, is thus fully confirmed.

On close investigation of the segregating families it was noticed that amongst the panicles bearing fatuoid grain those which were well and fully matured possessed grain which lacked

the yellow colour, whereas the grain of the less matured fatuoid panicles were distinctly greenish-yellow in colour. This was a very unexpected observation, which at first appeared to negative all conclusions in regard to the F_2 plants. On removing spikelets from one of these partly greenish panicles and drying them in an oven together with yellow *sativa* spikelets from similarly partly greenish panicles, it was found, after drying for forty-eight hours at a temperature of 50° C, that the greenish-yellow fatuoids became bleached in appearance and in the course of further drying all evidence of yellow colour practically disappeared. The yellow *sativa* grains, however, retained their yellow colour.

On harvesting these F_3 families some days later, a number of panicles with greenish-yellow fatuoid grain were still to be observed and also some similarly greenish-yellow intermediate types. After harvesting, the progeny of a number of these were separated into five types, viz. :—greenish-yellow and non-yellow fatuoids; greenish-yellow and non-yellow intermediates; and yellow *sativa*. Observations made on these after drying under ordinary laboratory conditions indicated that a loss of yellow colour takes place during drying in those panicles homozygous or heterozygous for the fatuoid character. One panicle heterozygous for the fatuoid character, however, appears to have retained a fair degree of yellow colour; whether this is a cross-over type or whether it may still lose its colour cannot at present be stated. All the yellow *sativa* panicles retained their yellow colour and all the originally greenish-yellow fatuoid types have, except for slight traces in occasional grains, lost the yellow colour.

Summarising the F_3 results, we obtain twelve families classified in F_2 as yellow-*sativa*, breeding true for these characters, and twenty-four families classified in F_2 as intermediates, segregating into fatuoids, intermediates and *sativa* types. The *sativa* types were yellow in colour and the fatuoid and intermediate types on arriving at complete maturity or when air-dried in the laboratory were, with the exceptions mentioned, whitish like the original fatuoid parent. The F_3 results thus confirm those obtained in F_2, the data on which were not taken until after a period of drying in the laboratory, when the greenish-yellow colour of the immature specimens of the fatuoid and intermediate types had practically disappeared.

Tentative Discussion.

Although the studies recorded above are only of a preliminary nature, they are of special interest in so far as they reveal a new aspect of the problem of the relationship existing between yellow

colour and the development of the fatuoid characters. Up to the present time these studies have centred upon the inhibitory effects of the factor for yellow colour, or of a factor linked with yellow, on the development of the normal *sativa* awn or upon the development of *fatua* type of awn and the characters associated with it. In all cases where negative correlations between these characters have been encountered they have been interpreted as being due to the inhibitory effect of the yellow colour or of some factor associated with it. Such an explanation, however, implies that some of the yellow-*fatua* segregates contain the *fatua* characters suppressed and therefore on crossing with white *sativa* should segregate white *fatua* types. No proof of this kind has yet been recorded.

In the material in the present investigation a similar negative correlation between yellow and the fatuoid character has been obtained, but owing to the absence of all factors for colour other than that for yellow the segregation is of a simple character and the relationship existing between yellow and the fatuoid character may be easily followed. Moreover, the appearance of a greenish-yellow colour in the immature fatuoid panicles and its subsequent disappearance show very clearly that the absence of yellow-fatuoid types is here not due to the inhibitory effects of the yellow colour or of any factor associated with it, but rather to the disappearance of yellow in these particular genotypes. Why the yellow colour should disappear from these genotypes remains a problem for further enquiry.

It would appear from the above that the results obtained by Love and Craig would admit of a similar interpretation. In a study of the segregation of the factors for black, grey and yellow colour of grain and for *fatua* and *sativa* types of grain they obtained a negative correlation between yellow colour and *fatua* type grain. The segregation for *sativa* and *fatua* types of grain gave good agreement with a unifactorial expectation and in the F_3 series showed uniform distribution in relation to the black and non-black colour classes. Within the non-black group, however, there was an excess of grey *fatua* types and a complete absence of yellow *fatua* types, which strongly suggest, owing to absence of yellow in the yellow *fatua* segregates and the resulting similarity phenotypically between these and pale greys, that the group grey *fatua* contains both grey *fatua* and genotypically yellow *fatua* types. Should this be the case the agreement here as in other details with the suggested interpretation is particularly good.

The absence of yellow colour as described above cannot, however, be considered as analogous with the absence of yellow,

strongly-awned types as found by Nilsson-Ehle, Love and Fraser, Fraser and others. Although the results are similar in so far as they exhibit negative correlations between the development of yellow colour and strong awns, they differ considerably in that in the fatuoid oat the strong awn is closely linked with the other characters which form the fatuoid complex, and from the present experiments it cannot be determined how much of this effect, if any, is due to the awn and how much, if any, is due to the other characters of the complex.[3] In the results recorded by Nilsson-Ehle the colour is stated to persist whereas the awn development is suppressed. This is the exact converse of what has been shown to occur here.

The appearance of yellow fatuoid plants in the variety Aurora as recorded by Garber, by Stanton, Coffman and Wiebe, and of yellow-*fatua* grains as recorded by Crépin and others tends to indicate that the behaviour of the yellow character in relation to the fatuoid and *fatua* characters differs in different varieties and with the different strains employed. It would be interesting, therefore, to enquire whether a similar divergency may not be found in the relationships existing between yellow and the normal or "cultivated" type of awn.

The whites of two classes, the one genotypically white and the other genotypically coloured, as found by Coffman, Parker and Quisenberry in the Burt variety, show certain affinities in this respect. Owing, however, to the data for the whites of the latter class being grouped with the coloured types for the study of correlations, figures for the separate study of the behaviour of the two white classes in relation to the degree of awning are not available for discussion from this standpoint.

In conclusion and in view of the inhibitory relationships already recorded, the question may be raised as to whether the loss of colour on ripening, as described in these studies, is to be regarded as an inhibitory effect due to the presence of the fatuoid complex or of some factor associated with it, or whether it should be regarded as an entirely separate phenomenon. The data give support to the latter view.

My grateful thanks are due to Professor R. G. Stapledon, M.A., M.B.E., for valuable help in the collection of relevant literature and for his keen interest in the progress of these investigations; to Mr. T. J. Jenkin, M.Sc., for helpful criticism; to Miss

[3] In this connection true breeding and apparently "semi-fatuoid" types, such as the writer has recently found, may prove of value in analytical studies of certain of the components of the fatuoid complex in relation to the yellow colour.

Rhoda Jones, B.A., for assistance in connection with the foreign publications cited, and to Mr. J. W. Watkins, Farm Superintendent, for much careful attention in connection with the plant cultures.

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FURTHER STUDIES ON THE INHERITANCE OF RESISTANCE TO CROWN RUST (*P. CORONATA*, CORDA.) IN F_3 SEGREGATES OF A CROSS BETWEEN RED RUSTPROOF (*A. STERILIS*) AND SCOTCH POTATO OATS (*A. SATIVA*).

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In an earlier paper[1] a detailed account was given of the mode of inheritance of resistance and susceptibility to crown rust in the F_1 and F_2 generations of a cross between selections of the varieties Red Rustproof and Scotch Potato. The segregation in the F_2 generation indicated fairly clearly that the inheritance of these characters is dependent on a single factor difference. Out of 1,085 seedlings inoculated under greenhouse conditions 777 showed characteristic resistance and 258 were definitely susceptible. Resistance thus appears to behave as a simple dominant and accordingly F_2 segregates classified as resistant should, in the F_3 generation, give pure breeding resistant and segregating families in a ratio of 1 : 2.

In order to verify this conclusion a number of F_2 seedlings were in 1925 grown on to maturity, and seed was obtained for further inoculation studies in the F_3 generation. The results of studies with these F_3 plants are given below and form the subject of the present paper.

From the F_2 segregates grown on to maturity a total of thirty-five plants were selected at random to provide seed from which to raise the next generation. Of these, twenty-nine had been classified in the seedling stage as resistant and six as susceptible.

In the spring of 1926 F_3 seedlings were grown in five-inch pots, under conditions identical with those recorded in the earlier paper. About sixteen grains of each family were sown per pot, that being the average amount of grain available for this purpose. The seedlings were in due course inoculated with uredospores obtained from cultures grown from the strain of rust previously used in testing the F_2 seedlings. Notes were made at regular

[1] See Davies, D. W., and Jones, E. T., this *Journal*, Vol. II, pp. 212-221, 1926.

intervals, and the classification of the seedlings into resistant and susceptible was based on the same type of reactions as were observed and recorded in connection with the F_2 generation seedlings.

The data in regard to the inoculations of the progeny of the six susceptible F_2 plants are given in Table I.

TABLE I.

Rust reactions of susceptible F_2 Plants in the F_3 generation.

Station reference number.	*Reaction to inoculation in F_2 generation.*	*Breeding behaviour in F_3 generation.*		*No. of seedlings inoculated.*
		Resistant.	*Susceptible.*	
691/120	Very susceptible.	nil	14	14
141	Very susceptible.	nil	15	15
144	Very susceptible.	nil	14	14
153	Very susceptible.	nil	12	12
169	Very susceptible.	nil	13	13
178	Very susceptible.	nil	15	15
	Total number of seedlings inoculated = 83			

Here it can be seen that of the eighty-three seedlings comprising the six different cultures all exhibited complete susceptibility, and all six families may be regarded as true breeding susceptible types. These data support the conclusion arrived at from the behaviour of the F_2 plants that the character "susceptibility to crown rust" in this particular cross behaves in inheritance as a simple recessive. Further confirmation of the unifactorial nature of the segregation is obtained from a study of the data given in Table II of the breeding behaviour of the F_2 plants classed as resistant.

In Table II it will be seen that ten of the twenty-nine F_3 families inoculated showed complete resistance and nineteen segregated into resistant and susceptible types in a manner identical with that obtained in the F_2 generation. The true breeding resistant and segregating families are in the ratio 1 : 1.9, and in this respect show close agreement with a 1 : 2 ratio such as would be expected upon a monohybrid interpretation of the results. It should, however, be pointed out that the number of seedlings in each F_3 family inoculated is small, but even if additional numbers of the families classed as pure resistant were tested it is very unlikely that any deviation from a unifactorial interpretation of the data would result.

The true breeding character of the susceptible families, which formed 25 per cent. of the F_2 generation plants, together with

TABLE II.

Rust reactions of resistant F_2 plants in the F_3 generation.

Station reference number.	*Reaction to inoculation in F_2 generation.*	*Breeding behaviour in F_3 generation.* *Resistant.*	*Breeding behaviour in F_3 generation.* *Susceptible.*	*Ratio of non-segregating to segregating families.*
691/114	Resistant.	14	—	10 families breeding true for "resistance".
116	Resistant.	13	—	
128	Slightly flecked.	14	—	
139	Resistant.	16	—	
148	Resistant.	15	—	
181	Resistant.	16	—	
183	Resistant.	16	—	
191	Resistant.	12	—	
193	Resistant.	14	—	
195	Slightly flecked.	14	—	Ratio = 1 : 1·9 Theoretical expectation (monohybrid basis) = 1 : 2
102	Resistant.	10	5	19 families segregating into "resistant" and "susceptible" types.
119	Slightly flecked.	14	1	
123	Resistant.	7	3	
135	Resistant with weak pustules.	8	6	
147	Resistant.	6	3	
149	Resistant.	8	4	
156	Resistant.	9	5	
157	Resistant.	10	4	
158	Resistant.	10	4	
159	Resistant.	13	3	
161	Slightly flecked.	9	5	
162	Heavy flecking with weak pustules.	10	2	
168	Resistant.	6	6	
173	Few weak pustules.	10	4	
174	Resistant.	10	4	
175	Resistant.	12	3	
176	Resistant.	12	3	
187	Resistant.	7	5	
189	Resistant.	11	3	

Totals for segregating families = 172 73
" Expected " on 3 : 1 basis :— 183·75 : 61·25

the total figures for the nineteen segregating F_3 families, are evidence of simple segregation. The agreement of 172 resistant to 73 susceptible with the " expected " 183.75 : 61.25 is not very close, but the divergence is not particularly great when the small numbers involved in each family are borne in mind. With the exception of family 691/119, where the number of susceptible plants is very low, and family 691/168, where the two classes occur in equal numbers, the proportions of resistant to susceptible in the F_3 segregating families show very marked regularity.

A comparison between the reactions to inoculations in the F_2 generation and the breeding behaviour in F_3 (see Table II)

reveals the fact that none of the homozygous resistant forms in the F_2 generation showed even slight infection : all were marked either as " resistant " or as " slightly flecked." On the other hand, of the segregating families in F_3, four were described in F_2 as exhibiting a very slight and partial development of uredosori. As the number of families tested is small the significance of this feature, as an indication of the heterozygous condition, cannot be established from the evidence available. Further tests with F_3 material should demonstrate whether any correlation in this direction actually exists. Owing, however, to the very few phenotypes (117 out of a possible 518)[2] showing this slight variability from the completely resistant condition it would not be possible, even with complete correlation, to identify all the intermediate types by this means. This fact is of importance to the plant breeder as the ability to distinguish between the homozygous and heterozygous resistant forms in the F_2 generation would greatly facilitate and minimise the work entailed in the production of improved strains of rust resistant varieties of oats. On the other hand, failure to do so necessitates either further tests of all the resistant types in the F_3 generation or a postponement of all inoculation tests to the F_3 families, when in order to determine the true breeding resistant forms a minimum of about thirty seedlings of each F_3 family must be dealt with. Such a procedure is extremely laborious, but these studies show that such a method is the only satisfactory means whereby true breeding resistant types can with certainty be isolated in the early hybrid generations.

Linkage Possibilities.

In a cursory examination of some of the pure breeding resistant F_3 seedlings grown to maturity during the present season the frequent appearance of certain undesirable grain characters, typical of the resistant parent, seemed to suggest the existence of a certain degree of linkage between these characters and that of resistance to crown rust. An association of this nature would add considerably to the difficulties of the plant breeder in producing rust resistant strains of a quality equal to that of our best *A. sativa* varieties; and an absolute linkage would, of course, preclude all possibility of the production of such types, however desirable.

The existence and degree of linkage, if any, is of fundamental practical importance and further investigations along these lines with the F_3 material are now in progress.

[2] See Davies, D. W., and Jones, E. T., page 218 *loc. cit.*

THE RELATIONSHIP BETWEEN VARIOUS FACTORS AND THE ASH CONSTITUENTS OF MILK.

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Introduction.

Investigations into the nutritive value of different grasses have been in progress at Aberystwyth for several years. Certain features in connection with their composition brought out during the summer and autumn of 1922-23 (1) have an important bearing on the feeding of live stock. In subsequent seasons these features have been found to hold for Scotch (2) and English (3) pastures.

The significance of these results in connection with the management of hay and pasture land has already been emphasised. In addition, it should be realised that some of the findings have an important bearing on the winter feeding of cattle, and that this is by no means solely due to the fundamental differences which have been elucidated between the dry matter of hay and grass. In connection with the total quantities of ash ingredients found present in a good pasture, it has been discovered that some of them are so abundant that the animal has ample opportunity of storing these during the summer. A reserve supply will thus be accumulated, which, on account of what is ordinarily provided by a winter ration, is not likely to be depleted. There are other essential ash ingredients, however, which, on account of their concentration in the food throughout the advancing summer and the immediate demands made upon them by the animal, cannot be possibly stored to any appreciable extent. It is to ingredients of this type that the dairy farmer's attention should be particularly paid when preparing his winter ration, so as to ensure that there is no undue drain on the animal's vitality which would result ultimately in a restricted supply of milk from his herd.

There is no doubt that there are other directions in which it would be profitable to consider the system of winter feeding in closer relation to summer grazing than has been the tendency in the past. For example, the "balanced" rations generally advocated for the winter feeding of dairy cows contain a very liberal supply of protein in excess of that actually required by an average dairy shorthorn for maintenance and production purposes. The reason for this is that as a result of extensive

experimental work it has been found that excess of protein acts as an important stimulant to the milk gland.

Whether a surplus of digestible protein is really required in the winter rations of this country in view of the superabundance of protein present in the pastures is a question which still remains to be settled. It was in order to throw light on questions such as the above that this work, the preliminary stages of which are reported in the present article, was undertaken.

Experimental.

The work was carried out in conjunction with a feeding experiment[1] on dairy cows at the College Farm, Aberystwyth. The object of the experiment was to compare a ration consisting of home grown foods and maize meal with a ration balanced in the ordinary way by the inclusion of cakes. The group system of feeding was adopted, one group of cows being fed for a period of two months on the home grown food, the other group being provided over the same period with the balanced or control ration. At the end of this time the groups were reversed, so that the animals previously provided with the home grown ration were now fed for two months on the control. The experiment was conducted in this way during the winter of 1925-26.

Both groups were provided with the same maintenance ration consisting of :—

20lb. roots.
6lb. straw.
12lb. hay.

The production ration, which was varied with the yield, was as follows for a three-gallon cow :—

"Control" Ration.	"Low Protein" Ration.
5.30 lb. oats.	6.20 lb. oats.
1.20 lb. linseed cake.	1.90 lb. barley.
1.20 lb. decorticated cotton cake.	1.90 lb. maize meal.
2.90 lb. palm kernel cake.	0.50 lb. wheat.

In addition to the above, 1lb. mash made up of equal quantities of bran and oats was added to both production rations irrespective of yield.

On May 11th summer feeding commenced, the animals being left day and night on pasture, and no other food given to those yielding two gallons and under. Higher yielders obtain 3lb. concentrated food for every extra gallon of milk. In the case of the control group this consisted of three parts decorticated

[1] This experiment was conducted by Professor Griffith and Mr. Phillips. The writers wish gratefully to acknowledge their indebtedness to them for all particulars in connection with it, and for the full sampling facilities which were provided.

cotton cake, one part palm kernel cake and one part maize meal. The low protein ration group was provided with the same quantity of food made up of one part maize meal and one part bran.

The quality of the milk at the College Farm has been studied in its relation to the above experimental rations and other factors that operated during the course of the experiment. For this purpose fortnightly samples of the morning and evening milk from three individual cows in each group were examined in the laboratory, while an analysis of the ingredients composing the rations was also carried out.

Composition of Experimental Rations.

1. *Digestible Protein.*

The first outstanding feature of the feeding experiment was that one group of cows was fed with a home grown ration lower in protein than the control ration with which the other group was provided. The following table shows how the digestible protein content of the two winter rations compared with each other, and with various standards that have been advocated for dairy cows.

TABLE I.

Digestible Protein Content of Daily Rations in Winter for Dairy Cows 10 cwts. live weight, producing milk containing 3.45% protein and 3.77% fat.

	Kellner. lb.	*Haecker and Woll* lb.	*Armsby.* lb.	*Wood.* lb.	*Experimental Rations.* *Control.* lb.	*Low Protein.* lb.
For Maintenance	0.65—0.85	·0.75	0.85	0.70	0.84	0.84
Daily Production of 1 gallon	0.55—0.65	0.51	0.47	0.60	0.55	0.35
Daily Production of 2 gallons ...	1.10—1.30	1.02	0.94	1.20	1.01	0.61
Daily Production of 3 gallons ...	1.65—1.95	1.53	1.41	1.80	1.47	0.87
Daily Production of 4 gallons ...	2.20—2.60	2.04	1.88	2.40	1.93	1.13

In arriving at the figures for the experimental rations from the analytical data Kellner's digestibility coefficients for ruminants have been used. Some difficulty was experienced in deciding upon the digestibility coefficient to be adopted for the hay. This factor, on which the amount of digestible protein in the maintenance ration so largely depends, varies enormously with the quality of the hay. Thus the figures given by Kellner range between 85 and 78 for different qualities. By using the first figure the amount of digestible protein present in the maintenance ration of this feeding experiment would only amount to 0.55lb., while using the last figure it would amount to 0.91lb. As the hay actually fed was of good quality and made under ideal conditions the digestibility coefficient of 65 was adopted for the crude protein, this being the mean value obtained from a number

of investigations by Kellner on the best type of hay. This gave a digestible protein content of 0.84lb. in the maintenance portion of the ration.

Table I shows that the amount of digestible protein in the control ration of the feeding experiment was in close agreement with that generally advocated for dairy cows giving milk of average quality. The amount of digestible protein in the low protein ration stands out in marked contrast to that present in the control. Assuming that .70lb. of protein was actually utilised by the animal for maintenance purposes, and that all protein in excess of this would be available for production, then a cow giving two gallons of milk on the control ration would receive 167% of the protein yielded in her milk from her feed, while a cow on the low protein ration would receive only 109%. Similarly a four-gallon cow would get 150% of her milk protein from the control ration, while only 94% would be available from the low protein ration.

2. *Starch Equivalent.*

The starch equivalents of the control and low protein ration were identical for cows yielding the same amount of milk, this being 6.5lb. for maintenance, with an additional 2.8lb. for each gallon of milk.

3. *Ash Constituents.*

In addition to the variations in the constituents of milk such as fat, protein, total solids and ash which are usually determined, the ash itself from practically all the samples taken in this experiment was subjected to a detailed analysis. Consequently, the acidic and basic radicles supplied to the animals become of special interest, and Table II indicates the amounts of calcium, potassium, phosphorus and chlorine provided daily by the two winter rations.

TABLE II.

Ash Ingredients supplied daily in Experimental Rations to Dairy Cows in Winter.

Ration A—Control Ration.
Ration B—Low Protein Ration.

	Lime (CaO). Oz.		*Phosphate (P_2O_5). Oz.*		*Potash (K_2O) Oz.*		*Chlorine (Cl). Oz.*	
	Ration A.	*Ration B.*	*Ration A.*	*Ration B.*	*Ration A.*	*Ration B.*	*Ration A.*	*Ration B.*
Maintenance only	2.250	2.250	1.336	1.336	4.899	4.899	2.274	2.274
Daily Production of 1 gallon	0.140	0.062	0.853	0.583	0.629	0.426	0.027	0.023
Daily Production of 2 gallons ...	0.263	0.107	1.483	0.943	1.113	0.707	0.051	0.043
Daily Production of 3 gallons ...	0.386	0.152	2.113	1.303	1.597	0.988	0.075	0.063
Daily Production of 4 gallons ...	0.509	0.197	2.743	1.663	2.081	1.269	0.099	0.083

With the exception of chlorine, where the difference between the two rations is negligible, the control ration supplies more ash constituents to the animal than the low protein, the main difference being found between the phosphorus content of the two rations. The bulk of the calcium, potassium and chlorine are derived in the case of both rations from the maintenance portion, but where high yielders are concerned the greater part of the phosphorus is obtained from the production part of the ration. The reason for this is that the chief source of calcium, potassium and chlorine is the hay. While the amount of these three constituents from the hay far exceeds that supplied by any other ingredient of the ration, the cakes and the cereals play an equally significant part in supplying phosphorus in so far as cows yielding three gallons and over are concerned. The various cakes supplied in the control ration are by far the richest food stuffs in phosphorus, hence the greater amount of phosphorus in the control ration.

The composition of the milk ash in this experiment was such that the following quantities of ash ingredients would be removed daily by a cow producing three gallons.

Lime (CaO).	*Phosphate* (P_2O_5).	*Potash* (K_2O).	*Chlorine.*
0.780oz.	1.120oz.	0.918oz.	0.442oz.

The winter rations would undoubtedly supply ample potash and chlorine to meet the requirements of the milk, but this cannot be said with reference to the lime and phosphate. Seeing that no more than one-half of the lime and phosphate in the food can be assimilated, there should be 1.6oz. lime and 2.2oz. phosphate in the ration to meet the above milk demand. In addition to this, 1.5oz. lime and 0.8oz. phosphate are generally regarded as necessary in the food for maintenance purposes, which makes the total demand on the ration up to 3.1oz. lime and 3.0oz. phosphate. It is clear from this and Table II that when even a moderate yield is being obtained, there is a deficiency of calcium in both winter rations, and a deficiency of phosphorus in the low protein winter ration.

Owing to the rich nature of the pasture in May the supply of all constituents for the animals was entirely altered at the commencement of grazing. Both groups would then be receiving a large excess of digestible protein and a large surplus of most ash constituents. These summer conditions will be referred to in greater detail when the changes which took place in the composition of the milk at this time are being considered.

Variations in the Principal Ash Ingredients of Milk.

Special attention has been paid to the ash ingredients of the milk during the course of this experiment with the object of establishing their relationship with one another and with various factors that may have a bearing on their concentration. This was considered desirable not only in order to find the exact demand made by the cow on the ash constituents of the food, but also because of the possibility that small but significant differences in one or more constituent might differentiate between the effect of the two rations on the animal's system.

1. *Effect of Individuality.*

As would be expected, there may be important fluctuations in the ash ingredients of milk from one individual cow to another. The nature of these fluctuations is shown in Table III, where cows at practically the same stage of lactation are grouped together.

TABLE III.

The Effect of Individuality on the Ash Constituents of Milk.

Group.	*Date of Calving.*	*Cow.*	*% Lime (CaO).*	*% Phosphate (P_2O_5).*	*% Potash (K_2O).*	*% Chlorine (Cl).*
1.	June 9, 1925	Sibyl	0.1854	0.2426	0.1753	0.0831
	June 26, 1925	Laura	0.1626	0.2098	0.1614	0.1305
2.	Oct. 17, 1925	Sally	0.1769	0.2389	0.1886	0.0851
	Oct. 28, 1925	Berrlers	0.1748	0.2301	0.2151	0.0916
3.	Dec. 13, 1925	Polly	0.1586	0.2180	0.1885	0.1098
	Dec. 27, 1925	Peg	0.1354	0.2014	0.1799	0.1207
4.	Jan. 23, 1926	Mabel	0.1684	0.2531	0.2097	0.0898
	Jan. 29, 1926	Rosie	0.1686	0.2485	0.1989	0.0898
	Feb. 5, 1926	Seren	0.1652	0.2470	0.2006	0.0728

The two cows of group 1, Sibyl and Laura, dried off at an early date after the commencement of the experiment in January, 1926, and the figures in their case consequently represent the mean of a relatively small number of samples. Towards the end of a lactation period there are abrupt changes in the concentration of some of the ash ingredients of the milk. This is notably the case with the chlorine, which tends to rise very rapidly. Hence it is probable that a closer agreement would exist between the ash ingredients in the case of Sibyl and Laura had the milk for a greater part of the lactation period been analysed.

With Polly and Peg, on the other hand, a larger portion of the lactation period has been under observation, and the variations in the ash ingredients are here due to profound differences in individual behaviour. While giving a higher yield of milk than Polly during the first two months (January and

February) of the lactation, Peg then started to diminish in yield until in July it only yielded a third of the milk given by Polly. This diminution in yield was found to be accompanied by a marked decrease in the percentage of calcium and phosphorus of the milk.

While a wide discrepancy is found in this way between some individuals, there are others having calved at the same time that give milk very similar in ash composition. This similarity is especially evident in the calcium and phosphorus content of the milk of Sally and Berriers (group 2), while a close agreement in the same constituents is also found to occur in the milk of the three cows from group 4.

2. *Changes in Ash Constituents with Advancing Lactation.*

While milk at all stages in the lactation has been examined, only the most important changes will be considered at present. Owing to the variable nature of the changes at the beginning and end of a lactation an extended enquiry to include a larger number of animals and different breeds will be necessary before they can be considered in greater detail. Thus the colostrum compared with ordinary milk is characterised by a very high calcium, phosphorus and chlorine content. While the chlorine content becomes normal within the first two days after calving, the calcium and phosphorus diminish gradually and only reach the normal level in about a fortnight to three weeks. After this normal has been attained there are still changes continuing throughout the lactation, which to a certain extent are governed by the rate of flow of the milk. Thus all the ash ingredients are at their lowest level when the flow of milk is at its highest. The converse also applies in the case of the calcium and chlorine. Of all the ash ingredients the calcium is more closely related to the yield than any of the others.

The potassium and phosphorus change in such a way as to suggest a close relationship with the vitality and the fundamental life functions of the animal. They both reach their zenith about the same time before the middle of the lactation period, but subsequently their behaviour is entirely different. After reaching its maximum concentration the potassium only fluctuates within narrow limits till near the end of the lactation, a distinct lowering of concentration occurring as the cow dries off. A lowering of potassium also takes place if the health of the animal suffers so as to affect the gland.

The concentration of phosphorus after reaching its maximum about the same time as the potassium immediately falls and apart

from occasional breaks it continues to diminish as the lactation advances. This is significant in view of the narrow margin between the supply of phosphorus and the demand made on it by the animal during a complete cycle of summer and winter feeding (see page 245). The concentration of phosphorus like that of potassium is sensitive to those factors that affect the gland. An example of this is the case of a cow that suffered from a complaint arising out of fatigue known by the butcher as blain ("blade" or fothell). The diminished activity of the gland which resulted was accompanied by a lowering of the concentration of both the phosphorus and the potassium.

3. *Changes in Concentration of Ash Ingredients with Food, Yield and Season.*

The demand on the ash constituents of the food depends not only on the yield of milk but also on whether the concentration of these ash ingredients is constant as the yield of milk increases. Consequently, those changes in the ash which synchronize with the flow of milk are of considerable importance, and in Table IV the ash constituents during a period of four months' winter feeding have been arranged so as to bring out any variations that may be taking place with yield. Thus the figure .1733 given under the lime column (ration A) is the average lime content for the cows during this period which were fed with the control ration and yielded up to 2½ gallons of milk. The results obtained when the cows were out on grass have been arranged with the same object in view.

TABLE IV.

Percentage Ash Ingredients in Milk from Cows on Different Rations in Winter and Summer.

Group A—On Control Ration.
Group B—On Low Protein Ration.

	% *Lime* (CaO). *A.*	*B.*	% *Phosphate* (P_2O_5). *A.*	*B.*	% *Potash* (K_2O). *A.*	*B.*	% *Chlorine* (Cl). *A.*	*B.*
1. Winter Feeding— 15/1/26—10/5/26.								
Yielding up to 2½ gallons	.1733	.1737	.2290	.2310	.1803	.1893	.0998	.0906
Yielding over 2½ gallons	.1569	.1549	.2259	.2298	.1882	.1880	.0919	.0929
Summer Feeding— 11/5/26—2/8/26.								
Yielding up to 2½ gallons........	.1763	.1703	.2346	.2309	.2068	.2118	.1031	.0979
Yielding over 2½ gallons	.1582	.1495	.2340	.2294	.2040	.2067	.0953	.0949

The above table clearly shows that the different rations had no permanent effect on the composition of the milk. The average composition was practically identical for the two rations in

winter. A slightly higher calcium and phosphorus concentration was obtained in summer from the control group. As, however, the difference was the same for high and low yielders it has to be attributed to disturbing factors such as individuality and lactation rather than to any specific effect of the food.

The marked diminution in calcium content with increasing yield which occurs with both rations in winter and summer emphasises the close relationship between the concentration of calcium and the flow of milk. The rise in potash concentration from winter to summer shows that the potash of the milk is to a certain extent dependent on the season.

4. *The effect of grass on the ash constituents of milk.*

It has been already mentioned that the supply of nutrient in summer would be markedly different from that obtained in the winter ration. This applies to all the ash constituents with the exception of phosphorus.

The amount of grass consumed per head per day would be approximately in the neighbourhood of 30lb. dry matter. On this basis the following ash constituents[2] would be supplied daily under the system of summer feeding adopted.

TABLE V.

Ash Ingredients supplied daily in Experimental Rations to Dairy Cows in Summer.

Ration A—Control Ration.
Ration B—Low Protein Ration.

	Lime (CaO). Oz. A.	B.	*Phosphate (P_2O_5). Oz.* A.	B.	*Potash (K_2O) Oz.* A.	B	*Chlorine (Cl). Oz.* A.	B.
Maintenance only	4.99	4.99	3.36	3.36	16.22	16.22	5.18	5.18
Maintenance and Daily Production of 1 gallon	4.99	4.99	3.36	3.36	16.22	16.22	5.18	5.18
Maintenance and Daily Production of 2 gallons	4.99	4.99	3.36	3.36	16.22	16.22	5.18	5.18
Maintenance and Daily Production of 3 gallons	5.09	5.02	4.05	3.96	16.84	16.64	5.20	5.20
Maintenance and Daily Production of 4 gallons	5.19	5.05	4.74	4.56	17.46	17.06	5.22	5.22

A comparison of these figures with the amounts of ash ingredients supplied daily in the winter rations (see Table II, page 239) shows that even the pasture alone afforded a much more liberal supply of calcium, potassium and chlorine, but that there was not much difference in the phosphorus where high yielders were concerned.

[2] The analytical data for the pasture on which these figures are based were kindly provided by Mr. Fagan.

Although the supply of ash ingredients given in Table V are those obtainable under the conditions prevailing in May, the results from the analysis of pastures at Aberystwyth (1) with advancing season show that the mean phosphorus content fluctuates within narrow limits only, from one month to the next. The concentration of calcium, on the other hand, is generally greater in June, July and August than in May (2, 3). As a result the animals would receive a considerably more limited supply of phosphorus than of calcium in a complete cycle of summer and winter feeding, and this was especially the case with those fed on the low protein winter ration.

Any effect which the change to grass might produce was followed by sampling the milk immediately before the cattle were let into the meadow, and then sampling again after they had been grazing for a fortnight's time. The temporary fluctuations in the calcium and phosphorus at this period are of decided significance, and these are given in Table VI.

TABLE VI.

The Temporary Effect of Lush Grass on the Lime and Phosphate Content of Milk.

Group A—Fed on Control Ration before grazing.
Group B—Fed on Low Protein Ration before grazing.

	% Lime (CaO).		% Phosphate (P_2O_5).		Phosphate-Lime Ratio.	
	Before. Grazing.	*After Grazing.*	*Before Grazing.*	*After Grazing.*	*Before Grazing.*	*After Grazing.*
Group A.:						
Seren	.1691	.1623	2476	.2625	1.46	1.62
Berriers	.1648	.1715	.2251	.2247	1.37	1.31
Polly	.1631	.1512	.2122	.2157	1.30	1.43
Group B.:						
Mabel	.1684	.1729	.2435	.2751	1.45	1.59
Sally	.1912	.1802	.2402	.2478	1.26	1.38
Peg	.1372	.1341	.2042	.2213	1.49	1.65

The above table shows that one cow, viz., Berriers, stands out in marked contrast to others in that the lime content of the milk is increased, while the phosphorus is diminished and the phosphate-lime ratio consequently lowered as a result of grazing. It is interesting to note that it was the only cow in the experiment that was kept continually indoors up to May 11th. In the case of the other five cows, although the effect of grazing on the calcium and phosphorus varies considerably from cow to cow, the phosphate-lime ratio has invariably increased, and this increase is of the same order throughout. The abnormality observed with Berriers was found to occur with another cow, Nancy Pet, which had been similarly confined indoors but not included in the experiment. This indicates that the previous

management of the cow has a bearing on the fluctuations occurring in the ash at the commencement of grazing.

When the cows were put on pasture it is seen that a greater increase in the phosphorus of the milk from group B occurred than in that of group A. This is important in view of the relative paucity of the low protein ration in phosphorus, and also in view of a greater increase in protein, which, as shown further on, also took place at this time in the milk from the group on the low protein food.

Variations in Milk Ingredients other than Ash.

The effect of factors such as individuality and lactation on the fat and protein of milk have been along the lines indicated as the result of the investigation of other workers, and therefore need not be dealt with in this connection. Of more immediate interest is the effect of the two rations used in the experiment on the percentage composition of these ingredients in the milk. The rations were found to have no effect on the mean values for the protein, fat and solids not fat; but the cows which had been fed on the two rations in winter were found to respond somewhat differently to grazing. While only the control group received a surplus protein supply in winter, the pasture in May provided both groups with abundance of protein. Thus a two-gallon cow in both groups would receive about 3.60lb. digestible protein, while a four-gallon cow in the "control" group would be getting 4.60lb. against 4.14lb. available to the other group. This means that a cow giving two gallons would receive 420% of the protein yielded in her milk from her food, while a four-gallon cow would receive 250%—280%, depending on the kind of ration used to supplement the grass. Consequently any changes which occurred in the composition of the milk on passing from the relatively low protein level of the food in winter to the exceptionally high level at the beginning of the summer feeding are of the first importance, and these have been ascertained by comparing the composition of the milk immediately before and a fortnight after the commencement of grazing.

It should be borne in mind that the variations in the protein shown in the following table are of far greater significance than the fluctuations in the fat and solids not fat. The reason for this is that the fat and solids not fat are liable to be seriously affected by the prevailing circumstances at the time of milking, so that large differences often occur in these constituents from one fortnight to the next. Such differences would naturally tend to mask any specific action which the grazing might produce. In

order to ascertain the true effect of grazing on the fat and solids not fat much more frequent determinations at shorter intervals of time would therefore be necessary.

TABLE VII.

The Temporary Effect of Lush Grass on the Protein, Fat and Solids not Fat of Milk.

A—On Control Ration before grazing.

B—On Low Protein Ration before grazing.

Cow.	Daily Yield (Galls.)	Protein.		Fat.		Solids notFat :	
		Before Grazing.	*After Grazing.*	*Before Grazing.*	*After Grazing.*	*Before Grazing.*	*After Grazing.*
Group A. : Seren	4¼	3.12	3.44	3.75	3.78	9.59	9.25
Berriers	2½	3.34	3.41	3.55	3.78	9.09	9.24
Polly	3¼	3.48	3.58	3.75	3.68	9.13	8.98
Group B. : Mabel	3¼	3.32	3.71	3.38	3.98	9.04	9.13
Sally	1¼	3.77	4.02	3.85	3.23	9.56	9.93
Peg	2½	3.26	3.37	3.60	3.38	8.57	8.72

The protein content, on the other hand, is relatively constant from week to week for the same cow, and is obviously less sensitive to those accidental circumstances that influence the percentage fat. When this is taken into consideration the rise in protein which has occurred after a fortnight's grazing is of particular interest.

This rise has taken place with all the animals in the experiment. If Sally is left out of consideration the increase becomes greater in each group as the yield of milk increases. Thus in group A the protein in the milk of Berriers, giving 2½ gallons, is increased by 0.07%, while that of Seren, giving 4¼ gallons, by 0.31%. The increase in the case of Sally is abnormally high because this cow was approaching the end of her lactation, and the rise in protein was partly due to this factor.

The figures indicate that there has been a somewhat greater rise in protein in the milk of cows on the low protein ration. This is most marked in the case of cows yielding over three gallons. Peg, yielding 2½ gallons on the low protein ration, shows an increase in protein of 0.11% compared with .07% for Berriers, which gives the same yield on the control ration. An increase of .38, however, occurs with Mabel, giving 3¼ gallons, compared with only .10 in the case of Polly on the control ration.

This greater increase found to take place with group B may possibly be due to the restricted amounts of either (*a*) phosphate, (*b*) protein, or (*c*) both these constituents in the low protein winter ration. The behaviour of the high yielder, Nancy Pet, on being put out to grass at the same time lends support to

this view. This cow, unlike any of the others in the experiment, was consistently fed with the control ration throughout the winter. In addition, this ration was supplemented in her case with 2oz. of bone meal per day from February 7th, and with a similar allowance of salt from March 9th. One finds that the rise in the protein of her milk as a result of grazing only amounted to .09% in spite of the fact that 4½ gallons of milk were being produced at the time.

Summary and Conclusions.

1. Changes in the ash constituents of milk with individuality, lactation, yield and season have been investigated. The results obtained from the milk of shorthorn cows under the feeding conditions described in the article indicate that :—

(*a*) A close relationship existed between the concentration of calcium and yield during the period of seven months dealt with in this paper.

(*b*) The chlorine content varied within wide limits, especially at the beginning and end of a lactation.

(*c*) The concentration of potash was dependent on the proper functioning of the glands and on the season.

(*d*) Before the middle of the lactation was reached the concentration of phosphorus showed a tendency to diminish as the period advanced. The phosphorus content was also related to the activity of the glands.

2. The composition of milk, including the concentration of the ash constituents, is not affected by feeding for two months on a winter ration containing less than standard protein content.

3. An extension of the trial period over which a group of animals is kept on a low protein winter ration is justified in so far as the quality of the milk is concerned.

4. At the commencement of grazing a temporary increase in the concentration of phosphorus and protein occurred in the milk from the cows on both a balanced and a low protein ration. This increase was greater in the case of the milk from the low protein group. It is suggested that this may be connected with the lower amount of either (*a*) phosphorus, (*b*) protein, or (*c*) phosphorus and protein in the low protein ration.

5. The results show the advisability of adjusting the low protein winter ration so as to contain the same amount of phosphorus as the balanced ration.

The investigations dealt with in this article are still in progress, and are being extended so as to include the influence of other conditions on the ash constituents of milk.

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A STUDY OF SOME OF THE FACTORS GOVERNING CLEAN MILK PRODUCTION.

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Introduction.

The Clean Milk Competition organised in Brecon and Radnor during the first three months of 1925 was the first competition of this nature to be held in Wales.

The educational and practical value of this competition was soon realised, and as a result six similar competitions were organised in Welsh counties during 1926.

The results obtained from forty-one farmers distributed over the five counties of Brecon and Radnor (second competition), Carmarthenshire, Montgomeryshire and Pembrokeshire are surveyed in this article.

Table I shows the period of duration of each competition, the number of competitors in each, the number of samples examined, and the interval at which samples were taken.

TABLE I.

COMPETITION.	*Time of Duration.*	*Duration of the Competition.*	*Number of Competitors.*	*Number of Samples sent in by each Competitor.*	*Number of Surprise Samples*	*Total Number of Samples for each Competitor.*	*Number of Samples from each Competition.*	*Intervals at which Samples were examined*
Brecon & Radnor	Febr. to June	5 months	10	6	3	9	90	3 weeks
Carmarthen	Febr. to April	3 months	13	5	2	7	91	2 weeks
Montgomery....	Jan. to April	3 months	10	6	2	8	77	2 weeks
Pembroke	Jan. to March	3 months	8	4	2	6	48	2 weeks
TOTALS			41				306	

In the case of two of the competitions (Carmarthenshire and Pembrokeshire) the competitors were divided into two classes: Class A for holders of Certified or Grade "A" licences, and Class B for farmers not holding these licences.

Classification of this nature encourages keenness amongst the competitors in each class, and the formation of another class for competitors with small herds of twelve or under (as in the Brecon and Radnor competition) would seem worthy of a trial in future competitions in Wales, especially if the number of competitors increase to any considerable extent.

Milk Hygiene.

The whole secret of the production of clean milk is to make sure that the milk comes into contact as little as possible with dust or dirt of any nature from the moment it is drawn from the cow until it is consumed. It is now well known that all failures of milk, such as early souring, putrefaction, formation of taints, and ropiness are due to the addition of bacteria. These organisms may be derived from the udder and flanks of the cow, the hands and clothes of the milker, the air, bedding and food in the cowshed, or from the utensils and churns.

We also know that milk as drawn from a healthy cow is practically sterile, and that a few minutes' exposure to steam or boiling water will kill all bacteria, whilst the rate of increase of bacteria by multiplication becomes negligible at low temperatures of 50° Fahrenheit and under. The optimum temperature for the various bacteria found in milk lies between 60° and 80° Fahrenheit. In order, therefore, to produce milk that will have a low bacterial content, and which will keep sweet and wholesome for several days, the following precautions are necessary:—

1. Cows must be kept clean and healthy.
2. The milker must keep his hands and clothes as clean as possible, and extra care must be taken while milking.
3. Cowshed kept light, clean and well ventilated.
4. All the utensils which come into contact with the milk should be kept scrupulously clean, and scalded or steamed regularly.
5. The milk cooled to as low a temperature as is possible under the existing conditions.
6. All these precautions must be carried out in a systematic manner throughout the year and on all occasions.

The production of milk of a keeping quality of three to four days in winter and two to three days in summer demands *constant attention to details.*

The results of the four Clean Milk Competitions under review show that milk of a very high standard of cleanliness and wholesomeness can be produced under practically the normal conditions existing on the majority of Welsh farms, providing cleanliness is ensured in the byre and dairy.

Out of 306 samples submitted by forty-one farmers distributed throughout South and Mid Wales only 24% were below Grade "A" standards for bacterial count and coli organisms. On the other hand, 76% attained Grade "A" standards and 62% Certified standards.

Keeping Qualities of the Samples.[1]

One of the most interesting results was in regard to the general improvement in the keeping quality and the decrease of the bacterial content of the milk during the course of the competitions. In Table II the average keeping times, together with the average temperatures of the samples on arrival in the laboratory, are given for the first and last series in each competition.

TABLE II.

Average Keeping Time of the Milk Samples.

	Competition.	*Average Temp. on arrival in Laboratory.*	*Keeping time at 60 deg. F. (days).*		
			Maximum.	*Minimum.*	*Average.*
First Series.	Brecon and Radnor	°F. 50·7	6·5	3·5	4·8
	Carmarthen	56·2	5·0	2·5	3·8
	Montgomery	52·3	4·0	3·0	3·6
	Pembroke	52·0	4·5	2·5	3·3
Last Series.	Brecon and Radnor	61·4	4·0	3·0	3·6
	Carmarthen	53·5	5·0	3·0	4·1
	Montgomery	54·9	5·0	2·5	4·1
	Pembroke	55·0	6·0	4·0	4·9

It will be seen that in the case of the Brecon and Radnor competition, which extended from February to June, the average temperature for the last series had increased by eleven degrees.

[1] For a description of the methods of testing the milk samples *vide* :— "The Bacteriological Examination of Milk from Breconshire and Radnorshire," by Dinah M. Evans and R. O. Davies. This Journal, Vol. II, 1926, pp. 168—180.

This had a direct effect on the keeping quality of this series, which only amounted to 3.6 days, whilst that for the first series was 4.8 days.

The average keeping time for the four competitions was 3.8 days in the case of the first series and 4.2 days for the last series. The averages for the other three competitions organised during the winter months were 3.6 days for the first series and 4.4 days for the last series. These figures show the improvement effected during the course of the competitions.

The average keeping time for a total of 115 samples of milk taken from over a hundred retailers in Mid Wales during the period extending from June to September, at an average temperature of 68°F, was 2.1 days.

Bacterial Content of the Samples.

Table III shows the average number of bacteria present per cubic centimetre of the milk.

TABLE III.

Bacterial content of the Milk.

Competition.	*Remarks.*	*Number of bacteria per cc.*		
		Maximum.	*Minimum.*	*Average.*
Brecon and Radnor	Av. of 90 samples.	230,000	250	15,500
Carmarthenshire	Av. of 91 samples.	750,000	210	31,300
Montgomeryshire	Av. of 77 samples.	750,000	630	87,200
Pembrokeshire	Av. of 48 samples.	750,000	575	181,600
Ord. Retail Samp.	Av. of 115 samples.	2,240,000	950	247,000

A noticeable difference is found between the bacterial counts for the samples submitted during the competitions and those for the retail samples. It is a noteworthy fact, however, that although the latter were taken from over a hundred different farms over 40% were above Grade "A" standards, showing that clean milk is being produced under existing conditions on a considerable number of farms in Mid Wales.

From Table IV it is seen that only 5% to 8% of the samples submitted during the competitions contained coli organisms in such a small volume as 1/1,000 of a cubic centimetre, whilst on the other hand 34% of the retail samples gave this indication of considerable manurial contamination.

TABLE IV.

Presence of Coli organisms.

COMPETITION.	Percentage of Milk Samples in which:— Coli orgms. not present in 1 cc.	Coli orgms. present in 1 cc.	Coli orgms. present in 1/10 cc.	Coli orgms. present in 1/100 cc.	Coli orgms. present in 1/1000 cc.
1. Brecon and Radnor	78	16	4	2	0
2. Carmarthenshire ...	47	16	12	16	8
3. Montgomeryshire ...	37	22	15	21	5
4. Pembrokeshire ...	29	25	15	23	8
5. 115 Retail Samples ...	13	12	21	20	34

Graph I indicates the average bacterial count per cubic centimetre, coliform organisms, and keeping qualities for each competitor. The forty-one competitors are arranged along the base line, and the three resulting counts along the vertical side, in decreasing order as they ascend. A very noticeable correlation is found between the three tests in practically all cases.

Some Factors influencing Bacteriological Results.

Through the courtesy of the County Agricultural Organisers for the four areas involved a good deal of valuable information was obtained as to the conditions, and methods used at the various farms. A comparison of some of the most important methods of procedure, with the bacteriological results, are given here.

A. *Cleaning Utensils.*

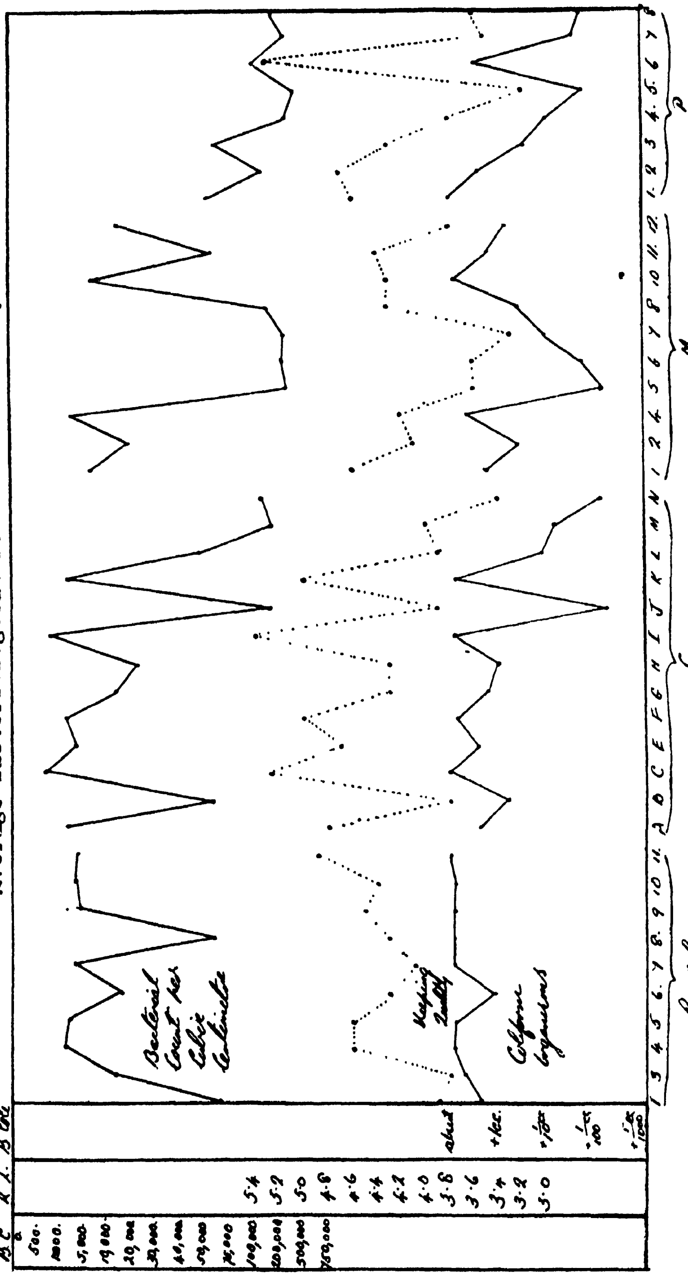
Table V shows that out of the forty-one competitors, eleven sterilised their utensils by steaming, while twenty-four scalded them satisfactorily, and six not so efficiently. For comparison, the results for samples obtained from ten farms not using properly scalding water are given. The water should be at or about 210° F. for correct sterilization.

Out of the thirty competitors who scalded their utensils, 80% succeeded in producing milk up to Grade "A" standards.

Graph II shows the bacteriological results in the case of eleven competitors sterilizing efficiently and six competitors using unreliable methods of scalding.

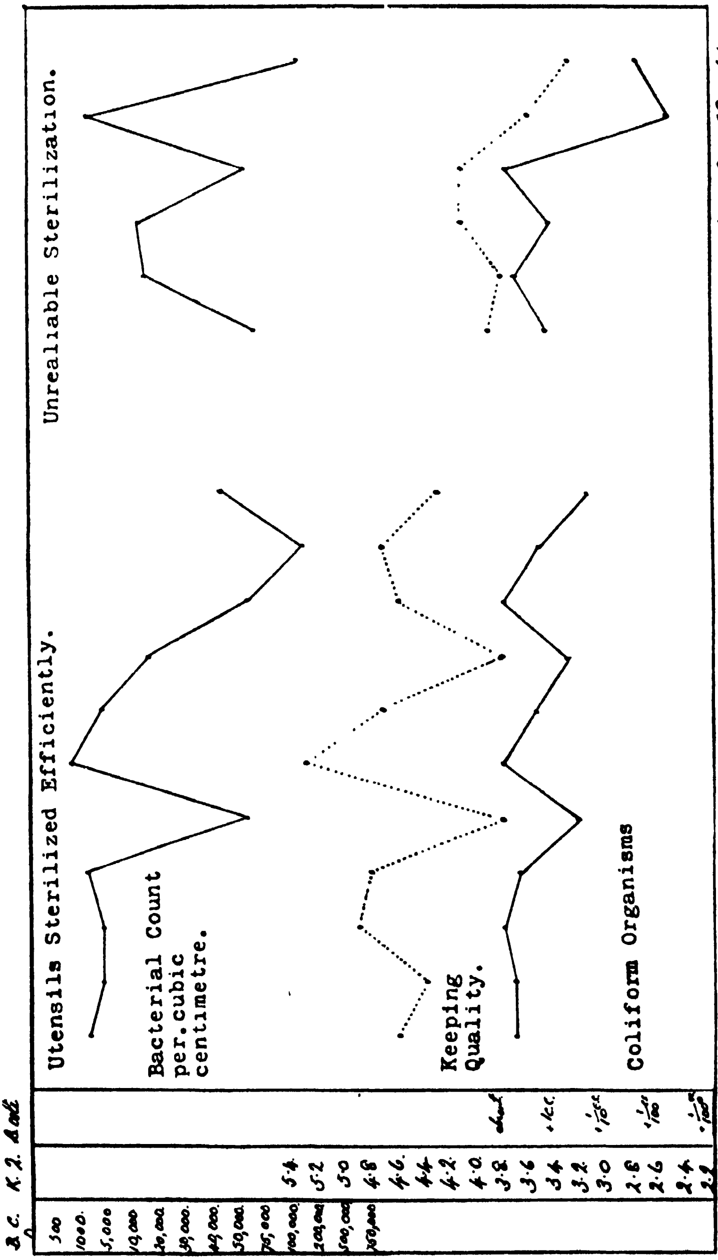
Graph I.

Average Bacteriological results for 41 Competitors.



B.C.—Bacterial Count. K.Q.—Keeping Quality. B.Coli.—Bacillus Coli.

Graph II.


Utensils Sterilized Efficiently.
Unrealiable Sterilization.
Bacterial Count per.cubic centimetre.
Keeping Quality.
Coliform Organisms
B.C.
K.Q.
500
1000.
5,000
10,000
20,000
30,000
40,000
50,000
75,000
100,000
5·4
5·2
5·0
4·8
4·6
4·4
4·2
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3·2
3·0
2·8
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2·4
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11.
12.
13.
14.
15.
34.
35.
36.
57.
1.
3.
6.
8.
28.
41.

TABLE V.

Methods of cleaning utensils.

	Av. number of bacteria per cubic centimetre.	*% samples in which Coli organisms were present.*	*Average keeping time (days).*
1. Efficient steaming. (11 competitors).	31,410	33	4·5
2. Fairly efficient scalding. (24 competitors).	90,330	54	4·2
3. Less satisfactory scalding. (6 competitors).	108,760	56	3·8
4. Ten retailers using water, not up to boiling point.	627,400	100	1·8

B. *Cooling, Straining and Milking.*

As three of the competitions finished in April, and the other in June, winter conditions prevailed throughout. The cooling factor was thus of not such importance as it would be in summer.

Immediate cooling of the milk keeps down the rate of increase of the bacterial content, but it should always be borne in mind that it is far better to aim at keeping the bacteria out of the milk altogether.

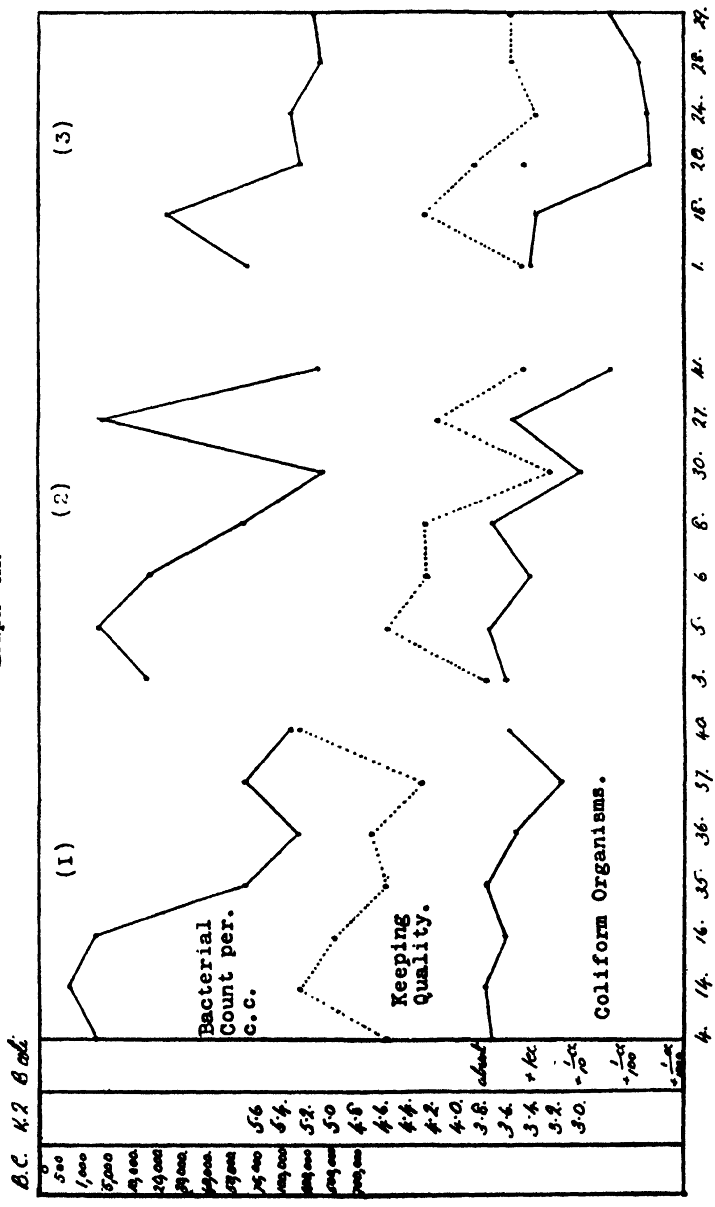
A study of Table VI and Graph III shows that the ultimate results are much worse in cases where the milk was cooled on farms with generally unsatisfactory methods than in the cases where the milk was not cooled but where the general methods were fairly satisfactory.

TABLE VI.

Cooling, Straining and Milking.

	Average number of bacteria per cubic centimetre.	*% samples in which Coli organisms were present.*	*Average keeping time (days).*
1. Milk cooled. Cotton wool discs used for straining. Covered pails used. (7 competitors).	52,790	28	4·8
2. Milk not cooled. Straining cloths used. Open pails used. (7 competitors).	86,650	43	4·0
3. Milk cooled, but general methods not satisfactory. (6 competitors).	152,400	86	3·8

Graph III.

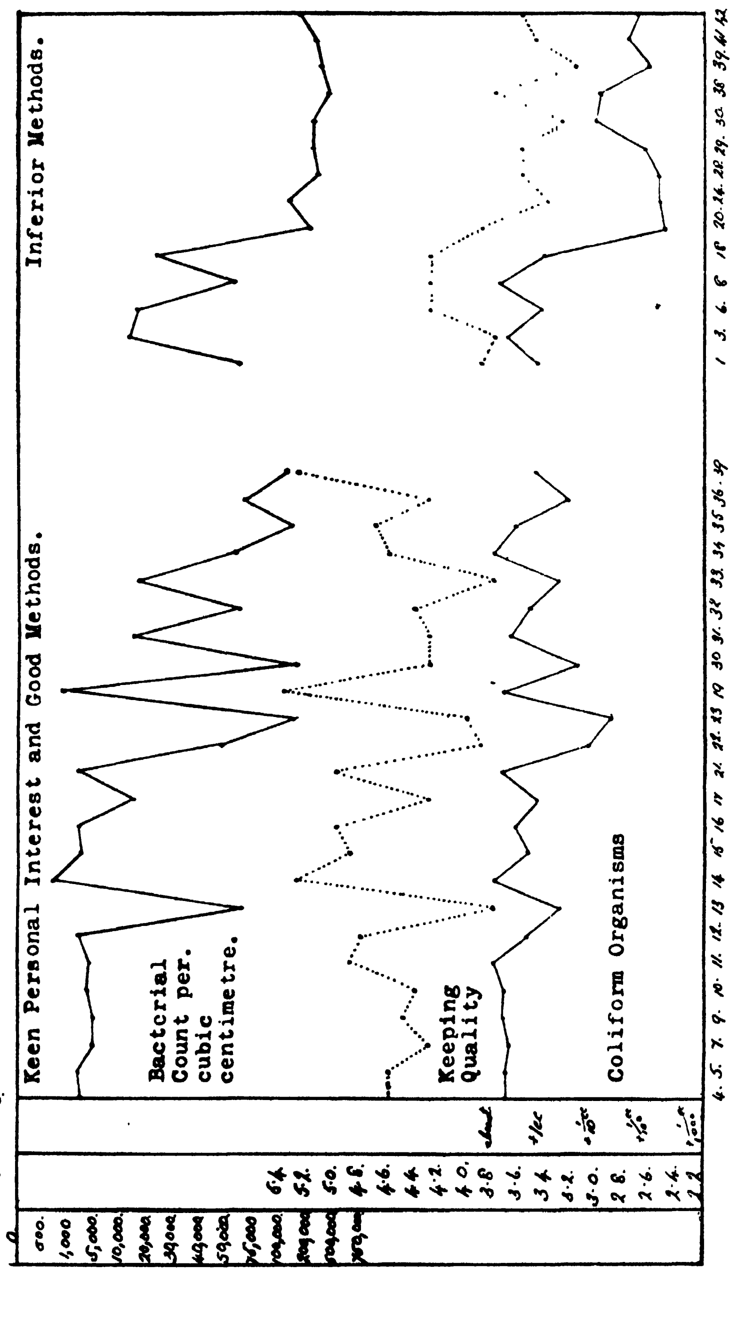


1. Milk cooled.
Cottonwool discs used.
Covered pails used.

2. Milk not cooled.
Straining cloths used.
Open pails used.

3. Milk cooled, but general cleanliness not good.

Graph IV.


Keen Personal Interest and Good Methods.
Inferior Methods.
Bacterial Count per cubic centimetre.
Keeping Quality
Coliform Organisms

Columns (1) and (2) show the different results attained by two groups of competitors; the first group using covered pails for milking, cotton wool discs for straining, and passing the milk over a cooler, while the second group of competitors used ordinary open pails, cloths for straining, with no cooling.

The difference is especially marked in the case of the average keeping quality and the percentage of samples in which coli organisms were present.

C. *The Personal Factor.*

Table VII and Graph IV show the importance of the personal factor in the production of clean milk. Due to the large number of limiting factors, it is difficult to estimate the exact effect of any one factor. The importance of the personal factor can never be over-estimated, however. The keen personal interest of the farmer and his employees generally results in improved methods and is characterised by special attention to details.

TABLE VII.

General Methods and Personal Interest.

	Average number of bacteria per cc.	*% samples in which Coli organisms were present.*	*Average keeping time (days)*
1. Keen personal interest, and general good methods. (24 competitors).	37,760	33	4·6
2. Inferior general methods and lack of interest. (14 competitors).	160,000	75	3·7

PRELIMINARY INVESTIGATIONS ON THE SEEDING DOWN OF PEAT LAND IN MERIONETH.[1]

By Moses Griffith, M.Sc.,

Agricultural Organiser for Merionethshire.

Introduction.

Great difficulty has always been, and still is, experienced by those farming the peat lands of Merioneth in getting a good take of seeds on black land. Many farmers, deeming it waste of money

[1] This paper forms a summary of the most important results obtained. The detailed results were given and discussed in the writer's major thesis for the degree of M.Sc. in 1926.

to buy seeds, simply sow hay loft seeds alone and wait for the indigenous grasses to fill up the large gaps invariably left in the swards.

Since this is an important problem for the county, a rather extensive trial to test various species and mixtures was laid out in 1923 on the farm of Mr. R. Roberts, Cefn Uchaf, Waen, Bala.

The rainfall in the district appears to be about seventy inches per annum; the altitude is about 950 feet above sea level.

The peat in the field where the experiment was laid out varies somewhat in depth, and lies on a glacial clay subsoil. A chemical analysis of the soil gave the following results :—

Moisture	9·35 per cent.
Loss on ignition	55·65 per cent.
Nitrogen	1·42 per cent.
Phosphoric acid (P_2O_5)	0·02 per cent.
Potash (K_2O)	0·035 per cent.

Lime requirement in calcium carbonate : four tons per acre.

The land under experiment was reclaimed from a tract of *mawnog* about fifty years ago, when it was drained, the drain pipes being laid at a depth of from four to six feet. Two crops of oats were taken and the field then seeded down with hay loft seeds under a bere barley nurse crop.

After about thirty years the field again came into cultivation and after crops of oats and potatoes had been taken it was seeded down in the same way as before. The take of seeds was very poor and several years elapsed before a full sward was obtained.

After grazing for twenty years the field was ploughed up in 1921 and a crop of oats was taken, with potatoes and roots following in 1922.

In the first week of June, 1923, it was again put down to grass, the present plots being sown without a nurse crop.

The oat crop in 1921 received no manure, but about twelve tons per acre of farmyard manure were applied for the 1922 crop. In April 1923, two months before the experiment started, a dressing of 3 cwt. per acre of Nauru phosphate and 8 cwt. per acre ground limestone were applied, while the young seeds were dressed with 5 cwt. per acre of basic slag in November of the same year.

Plan of Experiment.

(*a*) *Pure Species.*

In Table I a list of the pure species sown is shown, together with the amount of seed per acre, marks awarded for purity and density of sward in 1923, 1924 and 1925, as well as yield of green hay per plot in 1924 and 1925.

Duplicate plots of each species were sown, each plot measuring 7½ yards by 4 yards.

TABLE I.

Pure species plots; seed sown, marks awarded for purity and density, and green weight of hay per plot.

SPECIES.	*Seeds Sown. lb. per Acre.*	*Purity and Density Marks awarded: Maximum 100.* 1923	1924	1925	*Green Weight of Hay per plot in lb.* 1924	1925
1. Perennial rye-grass	25	90	80	50	98	48
2. Cocksfoot (commercial)	25	95	80	40	100	46
3. Cocksfoot (indigenous)	25	90	85	65	105	28
4. Timothy	15	95	95	90	167	90
5. Meadow fescue	25	50	70	50	125	38
6. Tall fescue (indigenous)	30	15	50	10	120	52
7. Meadow foxtail (commercial)	30	85	70	70	76	68
8. Meadow foxtail (indigenous)	30	90	80	80	73	68
9. Crested dogstail	20	70	70	30	113	42
10. Rough stalked meadow grass	10	85	70	65	87	42
11. Smooth stalked meadow grass	10	25	55	45	72	36
12. Alsike (English)	10	75	70	0	112	—
13. Alsike (Swedish)	10	80	75	0	127	—
14. Red clover (wild)	15	50	55	15	112	—
15. Red clover (Montgomery)	15	80	80	0	125	—
16. Red clover (Vale of Clwyd)	15	70	60	0	112	—
17. Red clover (Chilian)	15	40	7	0	—*	—
18. White clover (wild)	8	70	85	40	100	—
19. White clover (Dutch)	8	80	65	0	107	—
20. *Lotus corniculatus*	10	70	10	0	—*	—
21. *Lotus angustissimus*	8	20	0	0	—*	—
22. *Lotus major*	8	40	5	0	—*	—
23. Subterranean clover	10	90	0	0	—*	—
24. Strawberry clover	8	35	5	0	—*	—
25. Yellow suckling clover	8	75	0	0	—*	—
26. Lucerne	20	20	2	0	—*	—
27. Hubam clover (*melilot*)	15	65	0	0	—	—

* The sown species were only represented by a few plants on each of these plots.

The plots were periodically inspected and examined and notes were taken throughout the growing seasons 1923-25, and marks were awarded for density and purity of sward (Table I) on the following dates :—7th August, 1923; 17th May, 1924, and 18th June, 1925.

One series of clover plots were inoculated by means of soil from a field where clover had successfully been grown the previous year, but this did not noticeably affect either establishment or subsequent growth.

By June 1924, thirteen months from sowing, Chilian red clover, *Lotus major*, strawberry clover and lucerne were only nominally represented, while *Lotus angustissimus*, subterranean clover, yellow suckling clover and hubam clover had all completely disappeared. Most of the other clovers were then present in considerable quantity, as also were all the grasses. Outstanding amongst the clovers at this time, however, were Montgomery red clover, wild white clover and alsike, and among the grasses, timothy, cocksfoot, perennial rye-grass and indigenous meadow foxtail.

When yield of hay for this first harvest year is considered, the outstanding plot is timothy with 167 lb., the next being Swedish alsike (127 lb.) and meadow fescue (125 lb.).

By the second harvest year (1925) very little clover of any kind remained except wild white, and more sparsely, wild red. Amongst the grasses timothy, meadow foxtail and the meadow grasses best compare with the preceding year as far as density and purity of sward is concerned. In yield of green hay also timothy was still outstanding, with the foxtails coming next. In this respect commercial cocksfoot did better than the indigenous, while tall fescue in spite of low density and purity gave a relatively high yield.

It is evident from these results that red clover, alsike and white clover may under these conditions give a good account of themselves in the first harvest year and that they are better than any of the other species tried. At the same time there appears to be a fairly distinct difference between various strains of red clover. Such a difference is also evident in the case of the white clovers, although this does not become pronounced until the second harvest year.

From the evidence before us, none of the grasses tried appear to be entirely unsuitable for the conditions, but the least suitable seems to be tall fescue, whilst cocksfoot and perennial rye-grass do not seem to be well adapted to peat land.

(*b*) *Seeds Mixtures.*

The plots for the seeds mixtures were one-fortieth of an acre each, and were sown under the same general conditions and at the same time as the pure plots.

In series A, a basic mixture of grass seeds was used, while the leguminous constituents were varied. This, with a different mixture of grass seeds, was also the case in series B. Series C consisted of one mixture only, in which the Montgomery red clover was in similar amount to series A and B, while the grass seeds differed in kind.

In the first four plots of series D, a basal mixture of Montgomery red and wild white clover was used, while the grass seed constituents were varied. Plot D5 was given the simplest mixture of all, while for D6 a mixture of leguminous seeds only was prepared.

These plots, as in the case of the pure species plots, were kept under continuous observation, but in the present case a botanical analysis of the herbage was carried out in 1923, 1924 and 1925. A representative plot was selected for each seeds

mixture and from this ten circular turves each six inches in diameter were taken.

TABLE II.

Seeds mixtures and green hay yields.

			Seed per acre lb.	*Hay per plot in lb.*	
				1924	1925
Plot A1.	Timothy 12 lb. per acre. Crested dogs-tail 4 lb. per acre.	plus Montgomery red clover	7½	134	86
,, A2.		,, Alsike	5	140	88
,, A3.		,, Wild white clover	4	132	76
,, A4.		,, Subterranean clover	2	129	68
,, A5.		,, *Lotus angustissimus*	4	121	62
,, A6.		,, *Lotus major*	4	132	68
,, B1.	Cocksfoot 9 lb. per acre. Per. rye-grass 9 lb. per acre.	plus Montgomery red clover	7½	140	64
,, B2.		,, Alsike	5	138	60
,, B3.		,, Wild white clover	4	135	68
,, B4.		,, Subterranean clover	2	138	46
,, C1.		Meadow foxtail	9		
		Meadow fescue	9	151	60
		Montgomery red clover	7½		
,, D1.		Fiiorn (commercial)	8		
		Chewing's fescue	8		
		Montgomery red clover	4	163	66
		Wild white clover	2		
,, D1 (*b*).		As D1 plus *Bromus Schraderi*	12	165	70
,, D2.		Perennial rye-grass	8		
		Crested dogstail	4		
		Rough stalked meadow grass	4	140	74
		Montgomery red clover	4		
		Wild white clover	2		
,, D3.		As D2 except smooth stalked meadow grass instead of rough stalked.	4	138	68
,, D4.		Tall oat grass	4		
		Phalaris bulbosa	4		
		Montgomery red clover	4	152	74
		Wild white clover	2		
,, D5.		Perennial rye-grass	12		
		Wild white clover	4	120	44
,, D6.		Montgomery red clover	4		
		Alsike	2½		
		Subterranean clover	2		
		Lotus angustissimus	2	150	44
		Lotus major	2		
		Yellow suckling clover	2		

In 1923 the "percentage frequency" of each species only was used. This method was also used in 1924 and 1925, but at the same time the percentage by weight of each species in the total herbage was determined, while the total green hay yields of each plot was obtained by direct weighing (Table II).

The percentage frequency method used was that defined by Jenkin[2] as "the number of plants of each species per unit area, expressed in percentage of the total herbage." Jenkin's definition of a plant which in effect is equivalent to a tiller of a certain type was also followed.

In connection with the present work the merit of the method is that it takes into account the tillering vigour of the species while its drawback is that it may fail to show exactly what happens from year to year. Owing to tillering, therefore, the method may show a greater number of plants in the second than in the first year, while actually the number of entire plants may have decreased. In such a case, however, the vigour of the remaining plants is emphasised.

The full botanical results cannot here be presented, but they show that the clovers in every instance decreased in number of plant units from 1923 to 1924. In the same period rough stalked meadow grass, meadow foxtail, Chewing's fescue, crested dogstail and perennial rye-grass increased in number of plant units, while *Phalaris bulbosa*, meadow fescue, fiorin, timothy, cocksfoot and tall oat grass all decreased to a greater or lesser extent. A decrease in number of plant units in the course of the first winter, however, does not necessarily mean that the species concerned is not suited to the conditions, since timothy, with a decrease, formed an excellent sward.

During the second winter, 1924-25, the plots were heavily grazed, first with young cattle and later with sheep. As already shown, all the clovers except wild red and wild white in the pure plots disappeared completely during this period. In the seeds mixture plots there still remained on some plots traces of Montgomery red clover, alsike and *Lotus major* in addition to wild white clover, but as compared with 1924 each species, except wild white, showed a very marked decrease. Thus in plot A1 Montgomery red clover decreased from 5.48 per cent. in 1924 to 1.62 per cent. in 1925, and in plot A2 alsike decreased from 5.71 per cent. to 2.97 per cent.

In this period only two of the grass species disappeared completely. These were *Phalaris bulbosa* and *Bromus Schraderi.*

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[2] Jenkin, T. J., "Pasture Studies". Bangor, 1919.

Timothy held its own particularly well. In 1924 it formed from 69 per cent. to 79 pér cent. of the total herbage on the various plots of series A, and in 1925 from 59 per cent. to 66 per cent. Crested dogstail in the same period showed a further very decided increase on all plots where sown. Cocksfoot showed a considerable decrease, as also did perennial rye-grass. On plot C1 meadow fescue actually increased both in number of plant units and in percentage frequency, while meadow foxtail decreased very considerably. Rough stalked and smooth stalked meadow grass where sown increased in percentage frequency, while tall oat grass decreased. The figures for Chewing's fescue and fiorin are unfortunately incomplete, but the former showed no appreciable change in percentage weight, while fiorin showed a very considerable increase in this respect.

Hay Yields.[3]

As will be seen from Table II the hay yield per plot in 1924 ranged from 120 lb. on D5 to 163 lb. on D1(*b*) and in 1925 from 44 lb. on D5 and D6 to 88 lb. on A2. Within series A the highest yields in 1924 were from the alsike, Montgomery red clover, wild white clover and *Lotus major* plots, and in 1925 from the alsike, Montgomery red clover and wild white clover plots.

In series B there is little to choose between the first three plots in either year, but apparently in the first harvest year the basal mixture of cocksfoot and perennial rye-grass had been slightly more successful than timothy and crested dogstail; while in the second harvest year the reverse was the case. It is interesting to note that in both years the pure timothy plot gave a higher yield than when timothy was used in a mixture, and in fact a higher yield than was obtained from any of the mixtures used.

The meadow foxtail, meadow fescue and Montgomery red clover mixture of C1 gave a heavier yield in the first year than the Montgomery red plots in series A and B, but was less successful than the timothy with crested dogstail plot in the second year.

The inclusion of *Bromus Schraderi* in D1(*b*) seems to have had little effect upon hay yield as compared with D1, but both these plots gave relatively very good yields in the first year.

The substitution of smooth stalked meadow grass for the rough stalked had but a slightly depressing effect upon hay yield,

[3] The marked decrease in hay yield in the second harvest year is to a great extent due to late grazing by sheep followed by a period of drought, as the hay yields have increased again in 1926.

especially in the first harvest year (D2 and D3), while in spite of the complete disappearance of *Phalaris bulbosa*, D4 was one of the heaviest yielding plots in 1925. The very simple mixture used on D5 gave the lowest yield in 1924, and, with the pure leguminous plot D6, the lowest also in 1925.

Colonisation by Species Not Sown.

It is important to bear in mind, however, that these weights are totals for the herbage as a whole. A study of the degree of colonisation in the various plots as judged by the percentage weight results is interesting. These are given for the various plots in Table III.

TABLE III.

Percentage of total weight contributed by species not sown to the total herbage.

Plot.	1924	1925
A1.	4·58	1·96
A2.	5·46	1·20
A3.	1·47	0·99
A4.	1·35	6·73
A5.	1·59	1·32
A6.	3·65	3·52
B1.	6·76	6·67
B2.	1·14	5·65
B3.	3·03	5·65
B4.	3·27	36·00*
C1.	16·50	12·20
D1.	28·31	26·85
D1(*b*).	27·01	38·97
D2.	9·06	1·66
D3.	17·86	27·64
D4.	13·53	48·47
D5.	5·92	33·94
D6.	53·30	100·00

* Including 19·33 per cent. of miscellaneous herbs.

From this table it will be seen that the mixtures used in series A have resisted colonisation by unsown species to a greater extent than others, although some of those used in series B, and notably that used in D2, have been particularly successful. The deterioration in B4 from one season to another is particularly striking. On this plot the unsuccessful subterranean clover had been used. In series A the greatest deterioration also occurred on the corresponding plot.

In 1924 the greatest amount of colonisation was found on plots D1, D1(*b*) and D6. By 1925 the complete disappearance of *Bromus Schraderi* had resulted in further colonisation of D1(*b*), whereas there had been little change in D1.

The greatest colonisation of all was in the case of D6, where a leguminous mixture had been sown. In this case, by 1925 the crop consisted entirely of colonists.

Taking all the eighteen plots into consideration the most frequent colonists were wild white clover, rough stalked meadow grass, *Agrostis spp.*, annual meadow grass, *Ranunculus spp.* and daisies. The first three of these were recorded on all plots, while annual meadow grass and *Ranunculus spp.* were found on all but one.

In point of quantity rough stalked meadow grass was, as a rule, the most abundant colonist, although in some cases *Agrostis spp.* contributed to a greater extent to the herbage, the latter species accounting for nearly 48 per cent. of the total herbage of D6.

If the capacity of a seed mixture to hold the ground against colonisation, together with yield of hay in the second harvest year, be taken as the criterion of its success or otherwise, then the outstanding plots in the present experiment are A1, A2, A3 and D3. This means that timothy and crested dogstail with Montgomery red clover, alsike or wild white clover make a good mixture, while a mixture of cocksfoot with perennial rye-grass and any one of the three clovers, Montgomery red, alsike or wild white, is less successful.

Other Considerations.

In addition to the foregoing aspects of the general problem detailed results have been obtained on :—

(1) Establishment.
(2) Ratio of stem to leaf.
(3) Chemical analyses of the hay from the pure species plots.

These results, with supporting tables, were included and discussed in the original paper already referred to. They seemed to indicate that :—

(1) The degree of initial establishment does not of necessity prove whether a species is capable of persisting on peat land.

(2) In comparison with the same species grown at the Welsh Plant Breeding Station, Aberystwyth, the stem to leaf ratio is slightly higher on peat than on loam.

(3) Peat grown herbage of the same species, in a similar comparison, contained a lower percentage of protein and of silica.

Summary.

Of the eleven grass species sown alone, timothy was the most successful up to the end of the second harvest year. It maintained its density and purity of sward better than any other species and produced the heaviest yield of green hay in both the first and second harvest years. The pure timothy plot also outyielded all the seed mixture plots, not excepting those plots in which this species itself formed a high proportion of the seeding. Moreover, it showed some capacity for colonising plots on which it had not been sown.

Rough stalked meadow grass also did very well throughout in spite of the fact that the hay yield figures were not high. It filled up the sward very well, and by the second year it had invaded all the other plots in the experiment.

Meadow foxtail did relatively well in both years, but the indigenous strain formed a denser sward than the commercial, while the herbage was also finer and of a more prostrate habit.

Other grass lots which did fairly well were meadow fescue, perennial rye-grass and indigenous cocksfoot.

Of the sixteen species or varieties of leguminous plants tried, Swedish alsike and Montgomery red clover gave the highest hay yields in the first harvest year and maintained the best swards up to a point, but even these had practically disappeared by the second harvest year. In the first harvest year Vale of Clwyd red clover, white Dutch clover and English alsike also did rather well, but Chilian red clover suffered severely even in the first winter.

From a grazing and persistency point of view wild white clover did particularly well. It was the only leguminous plant (with wild red clover to a far smaller extent) to persist into the second harvest year, and within this period it had also colonised other plots to an appreciable extent.

It is probable that the persistency of at least some of the leguminous plants was adversely affected by grazing with sheep in the second winter.

Of the seed mixtures tried those in which timothy with crested dogstail formed the basis, with one of the three clovers Montgomery red, alsike or wild white added, were the most successful. They gave the best yield of hay and also formed the best swards. The wild white clover mixture in particular resisted the inroad of weeds very successfully.

In comparison with these, mixtures of which cocksfoot with perennial rye-grass formed the basis, with one of the clovers

Montgomery red, alsike or wild white added, were somewhat less successful.

Taking all the results into consideration, and bearing in mind also the general observations made on the plots, it would seem that as far as can be judged up to the end of the second harvest year the ideal seed mixture for peat land of this description and under similar conditions should consist of timothy, alsike and wild white clover, together with a bottom grass such as rough-stalked meadow grass or crested dogstail.

I am greatly indebted to Professor R. G. Stapledon, M.A., for kind assistance in drawing up the scheme of experiments, and for help in procuring seeds; to Mr. T. J. Jenkin, M.Sc., for assistance with the identification of plants and for much information and advice; to Mr. T. W. Fagan, M.A., and his assistants for carrying out the chemical analyses; and to Mr. A. R. Beddows, B.Sc., for giving me access to unpublished stem and leaf data.

A FEW OBSERVATIONS ON THE INCIDENCE OF TUBERCULOSIS OF THE UDDER IN COWS.

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The main object of these observations is to point out the need that exists for the warning and the instruction of those milk producers who are not in possession of tubercle-free herds concerning this, the most dangerous aspect of bovine tuberculosis to public health.

This desire has arisen as the result of the following factors :—

(*a*) The detection of numerous cases of clinical tuberculosis of the udder in milking cows in various parts of Britain.

(*b*) Finding that the owners or persons in charge of animals so affected were so often completely ignorant and without suspicion of the cause of the condition, which was almost invariably obvious in its manifestation.

(*c*) The comparative facility with which the tubercle bacilli can be microscopically detected in milk drawn from tubercular udders, and the small quantity of milk (a centrifuge tubeful only) which need be drawn from an

affected quarter for this purpose—which facts appeal to the writer's mind as being direct evidence of the large numbers of the bacilli capable of being excreted in such cases.

For the occasion of these observations, we will place on one side the following facts :—

(1) That there is, unfortunately, a tremendous (and unknown) number of dairy cows in this country affected to some extent or other with tuberculosis.

(2) That a cow affected to any extent with tuberculosis may, at any time, so develop the disease that she becomes capable of passing the bacilli in her milk (even without having shewn the udder to be clinically affected).

We, therefore, proceed solely with the animal that is suffering from tuberculosis of the udder.

To give some concrete indication of the incidence of this danger to public health, and the milk producers' ignorance, apathy, or whatever term is appropriate, the following fact may bear evidence.

In a certain county, very largely agricultural, in the course of the last ten months, thirteen cows were found to be suffering from tuberculosis of the udder. This was the result of the inspection of only a fraction of the dairy cattle in the whole of that area. Each of these thirteen cows had recently been passing tuberculous milk, which had been disposed of commercially or used for domestic purposes, or the manufacture of milk products.

(In case the foregoing be considered exceptional, the writer would state his opinion, after several years' experience with tuberculous bovines in various parts of the country, that this occurrence took place in a district that is comparatively fairly free from bovine tuberculosis when compared with certain others in which he has had experience).

Only in one of these thirteen cases mentioned did the responsible party suspect that tuberculosis may have been the cause of the abnormality present in the udder.

Some details of those cases may be of interest. As the result of a number (7) of pigs, all reared and fed upon the same farm, being found upon slaughter to be affected with tuberculosis, an inspection of the stock upon that farm was made, when the following cases of bovine tuberculosis were discovered :—

1. A cow suffering from a typically tuberculous udder—the milk from which, it was admitted, had been fed to the pigs.

2. A typically affected cow—the milk of which had recently been used to feed an infant of the person in charge, and subsequently, for the feeding of calves.
3. In this case a calf was seen to be sucking a particularly well defined tuberculous quarter.
4. A case of generalised tuberculosis, the udder being completely caseated or calcified in three of its quarters. This case had been producing milk which until recently had been disposed of commercially.

Tuberculosis of the udder is almost invariably the result of infection from another and previously involved organ. Whatever other lesions there may have been present, in a very large number of post mortem examinations made upon cows suffering from this form of the disease, the mesenteric lymphatic glands were quite invariably found to be affected and in nearly every instance these glands were showing distinct calcification. In one of the cases mentioned, except for a very small and apparently recent lesion upon the peritoneum, the mesenteric glands alone, in addition to the very typical udder, showed any tuberculous changes, after the most exhaustive search throughout carcase and organs.

From the veterinarian and pathologist's point of view it is interesting to note how very infrequently, on post mortem examination, is it found that the supra-mammary lymphatic gland is visibly affected in cases where the substance of the corresponding quarter is involved; and on the contrary, of course, instances do occur of the supra-mammary gland showing a caseating lesion whilst the udder is, at any rate, macroscopically, free, though milk from such an udder is always found infective bacteriologically.

Symptoms, etc.

The commonest characteristic of tuberculosis of the udder is that it is most frequently found to be affecting one hind quarter of the gland. A forequarter, the fore and hind quarters of the same side, both hind quarters, or any other combination may develop, but one hind quarter is by far the most usual. The development is gradual and diffuse, and to describe the development there is no term more fitting to the writer's mind than that of " insidious ". There is, one may say, almost an absence of any positively clinical symptom manifesting itself clearly and unmistakeably until the disease is well established. There is an enlargement taking place, very gradually during the first stages, and this is accompanied by an induration. These both frequently occur in the upper rather than the lower portion of the affected

quarter, and they proceed fairly rapidly when once they have been established, so as to be observable to the eye and touch. It is difficult to give a reliable indication of the time occupied in this development, as there are no records or observations available, but the writer has seen a definite enlargement and a pronounced induration to have taken place in a quarter during the period of six weeks. At the commencement of that period the udder was apparently normal to sight and touch. At the end of that time a hind quarter was " swollen, tougher and fuller ", as the cowman said when asked to describe what he could notice. Microscopic examination of the milk from that quarter showed tubercule bacilli to be present. With further progress the induration becomes marked and the affected part comes to feel as hard and stiff as wood, and eventually as bone, and several cases in the writer's experience have had the feeling of complete calcification. Such were, of course, quite old standing cases.

Other characteristic symptoms of tuberculosis of the udder are, if one may say so, almost negative in their manifestation. The enlargement and induration occur without warning—there is, usually, the absence of the other signs of inflammation, viz., heat and pain. This is of value from the diagnostic point, since most other changes in the udder substance proclaim themselves by enlargement, heat and pain. Then again, the appearance of the milk from a tuberculous quarter is not altered until the disease is quite far advanced therein, and the amount of milk, at first, is only very slightly diminished. As the disease becomes well established the quantity lessens and it eventually may become thin and watery or in very chronic cases it becomes a liquid resembling urine in colour and consistency.

It will be found that in most cases the act of milking does not in any way relieve the swollen condition if due to tuberculosis, and it is usually more easily detected after milking than before, as the enlargement of the udder due to the presence of milk may slightly assist in hiding the abnormality and make the quarters more regular in size before milking commences, whereas the abnormality is disclosed by the organ being emptied of milk.

An animal's condition is not necessarily or specifically affected by the udder being affected with tuberculosis. The condition is far more likely to retrogress on account of lesions affecting other internal organs or parts which were probably, as has been shewn, affected prior to the udder being involved.

It is not to be wondered at, altogether then, that the unenlightened or apathetic person seldom has his suspicion aroused by the symptoms of tuberculosis of the udder *per se* and

we are given to understand that a colossal number of children have suffered and died as a result of the consumption of milk thus produced.

Despite the recent enactments concerning the tuberculous cow and the purity of our milk supply, which only assist in the elimination of clinically affected cattle, nearly all of which are heavily infected, one longs to see some proof of the nation's encouragement to the production of milk from tubercle-free cows, and thereby the setting up of herds of cattle free from this disease.

It is readily admitted that this is an ideal entailing enormous expense and years of organised labour, but judged purely from the public health aspect, it appears to be absolutely essential, in the meantime, that health authorities undertake to have every milk-producing cow periodically examined by a qualified veterinary surgeon.

SOME OBSERVATIONS ON BRAXY IN SHEEP.

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The chief symptom of Braxy may be described as sudden death, which usually occurs after a frosty night. On post mortem examination, the abomasum (the fourth or true stomach), is found to be intensely inflamed, and there is often a considerable quantity of blood stained fluid present in the abdominal cavity. The kidneys may also be inflamed and there are often small haemorrhages on the inner surface of the heart. The inflammation in the stomach is itself somewhat characteristic, as it often manifests itself not diffusely, but in circumscribed circular areas of the size of a half-crown or five shilling piece.

Cause of Braxy.

This has been for many years a " bone of contention " among pathologists. Practically every investigator has found something definite and has been contradicted by a succeeding research worker, who has encountered in his turn the same fate. All appear to agree, however, that the condition is due to an organism; indeed they go as far as to agree concerning its nature, viz., that it is a bacillus. It is the actual type of bacillus about which they argue. The nearest approach to a successful elucidation of the

problem has been made by Professor Jensen, of Copenhagen, and Professor Gaiger, formerly of Glasgow, and now of Liverpool. Both these workers have succeeded in isolating from Braxy cases a bacillus from which they have each evolved a method of prevention which is apparently producing good results. The difference between the methods, very briefly, is this :—

In the method of Jensen a standardised quantity of the actual organisms is used, while in Gaiger's method no actual bacilli are injected but simply a solution of the Toxin produced by them.

It is rather remarkable that, in the literature on Braxy which has been available to the writer, the disease is not mentioned as occurring in Wales, although Scotland, Iceland, Scandinavia, the Faroe Islands, Australia, Tasmania, and Germany are all referred to as being countries where Braxy or Braxy-like diseases are prevalent. Yet it will be seen from the following observations that Braxy is and has been the cause of very severe losses in the Principality. Before entering into details it may be mentioned that the losses in the above countries varied between 6% and 50% before means of controlling the disease were discovered.

In 1924 the writer was consulted by a sheep-owner on the Gelligaer Mountain in Glamorganshire about an obscure disease which had for years been causing losses of up to 75% in flocks. Investigations were made with the result that the disease was discovered to be definitely Braxy.

From other information which gradually came to hand, Braxy was discovered also to occur in Monmouthshire, and information has also been received to the effect that it is prevalent in Breconshire, although this has not yet been verified. If any further proof were needed, other than the results of the writer's investigations, that the disease in Glamorgan, Monmouthshire and Brecon is identical with that in the South of Scotland, which is known to be Braxy, it would be the employment by some of the older farmers of the " pig-dung " treatment as a method of prevention. This method of treatment was supposed to have originated in and to be confined to the South of Scotland, where it has been on the whole successful. It consists of the dung of a pig, which has been fed on braxy land and cabbage, mixed with cows' milk, and the mixture fed to the sheep. One farmer stated that he used to obtain the pig-dung from Breconshire at 6d. a lb. The pound of dung was mixed with a quart of milk; the mixture was strained and the quantity was sufficient for twenty sheep. The farmer stated that he had had good results but that for some years past he had been unable to obtain the pig-dung, and besides

would be very thankful of a less tedious method of preventive treatment.

The farmers generally appear to have no specific name for the disease, although it was referred to by some as " Strike ". This name, unfortunately, appears to be applied to several fatal diseases of sheep. In Breconshire it is also known as " Strike " or " Planet ", or as a combination of the terms, viz., " Struck with the planet ".

Although death from Braxy is as a rule sudden, affected animals being usually found dead in the morning after a frosty night, a few are occasionally noticed to be ill some hours before death, when they seem to be moping, with hanging heads, apart from the rest of the flock, and showing signs of abdominal pain. In such cases some farmers cut a piece off the tail when, if bleeding followed, the animal was said to have recovered. Cross-examination has usually shaken such evidence. Indeed, many farmers have quite given up the practice as useless. The writer has seen several such attempts to save the life of an affected lamb, but in no instance have they been successful.

Once the existence of Braxy in the district was definitely established, it was resolved to test the Toxin method of Professor Gaiger, who kindly supplied a quantity of the vaccine for inoculation. Meanwhile, requests for inoculation of flocks were invited. These were rather slow in forthcoming; indeed, the majority of farmers, while expressing themselves as very interested in the treatment, were chary of allowing it to be tested on their own animals, but were assiduous in furnishing names and addresses of neighbours who had suffered losses from Braxy.

However, arrangements were finally made to inoculate some three hundred sheep, spread over ten farms, controls being kept in each case. The writer kept in personal touch with all the farms involved, and arrangements were made for immediate notification of any death in the flocks from whatever cause. The result was that during the Braxy season 1924-25 no deaths occurred amongst the inoculated animals while there were 7% of deaths from Braxy among the uninoculated. The season was, however, exceedingly mild from the Braxy point of view and all the farmers mentioned this fact but they were also unanimous in declaring that the inoculated sheep had wintered much better than the others. One farmer went so far as to credit the inoculation with being a preventive of Liver Rot. He based his opinion on the fact that he had sent twenty-four sheep—twelve inoculated and twelve uninoculated—to a certain part of the country where Liver Fluke was prevalent. All the uninoculated died from Liver Rot while

the inoculated all lived and did well. Needless to say the inoculation is not expected to have any such effect, but the above circumstance well illustrates the danger of deputing experimental methods of treatment to other people, and simply collecting and analysing a number of second-hand reports. It is the experience of the writer that many farmers and veterinary surgeons are inclined not to depreciate a new method of treatment but to *appreciate* it too highly, before its worth has been definitely proved, either from incurable optimism or from a desire to avoid hurting the feelings of the recommender of the treatment. Close and continued personal contact between the experimenter and his experiments is necessary if accurate results are to be obtained.

Bearing this in mind, and also the comparative mildness of the 1924-25 Braxy season, the writer attempted to arrange to repeat the inoculations in the autumn of 1925, but this for various reasons was found to be impossible.

This year, through the kindness of Mr. Dalling, a former assistant of Professor Gaiger, and now of the Veterinary Laboratories of Messrs. Burroughs Wellcome, a quantity of Braxy vaccine was again allotted to the writer, who once more sent out invitations for requests for the treatment. This time the difficulty was to keep the number of requests within limits. It was found that during the season of 1925-26 when no inoculations were carried out, deaths from Braxy had reached 30% and over in some flocks, although the season was not what might be called severe.

In all, 1,571 animals were inoculated by the writer in Glamorganshire and Monmouthshire. No casualties resulted from the inoculation either this year or in 1924. The animals were rendered lame for from three days to a week, but did not lose their appetite or suffer loss of condition in any way.

The Inoculation.

The inoculation is carried out in two stages, with a fortnight's interval between. The injection is made on the inner surface of the thigh, just above the stifle joint. The second inoculation is carried out on the opposite thigh. With adequate assistance in catching the animals, inoculations can be carried out comfortably at the rate of four a minute.

As the ensuing season promises to be rather severe, it is hoped that valuable results will be obtained as to the efficiency of the treatment in Wales.

VERMINOUS BRONCHO-PNEUMONIA IN THE PIG, DUE TO METASTRONGYLUS APRI,

WITH OBSERVATIONS ON THE CHLOROFORM METHOD OF TREATMENT.

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Some three years ago the opinion of the writer was asked on respiratory affections of obscure origin in pigs. The outbreaks occurred in each case in high-lying localities about seven or eight miles apart, the pigs, however, being obtained from different sources.

The condition was discovered to be that of Verminous Broncho-Pneumonia, and the history of the cases investigated follows, together with notes on succeeding investigations :—

Case 1.

This outbreak occurred on premises belonging to a business man whose hobby was the experimental feeding of pigs. The history of the case before the writer was called in is as follows :—

Six pigs were purchased from a litter of eight which were farrowed on rather low-lying marshy ground. When purchased, a slight intermittent cough was noticed, but was thought to be of no consequence. This cough, however, became more pronounced and the animals, after doing well for a few weeks, ceased to make any progress, although they continued to eat well. About a fortnight after the pigs had ceased to put on weight two died suddenly, and post mortem examinations were held on each of them. Bronchitis was the only pathological appearance noted. The lungs were especially mentioned to the writer as being healthy in appearance, as Pneumonia was suspected. The remaining four pigs continued to cough, the latter gradually becoming worse. Appetite, however, was maintained, although the animals began slightly to lose flesh. The case of the two deaths was reported as suspected Swine Fever, although there were no signs of that disease, and the suspicion was later negatived. The writer was then communicated with and visited the premises. The pigs at this time were between two and three months old. They were housed in a shed with a corrugated iron roof. The front of the shed had been open, but had been boarded up since the death of the aforementioned animals.

The pigs were coughing very badly, arching the back, and straining at each paroxysm. The cough was of the "husky" type, and was particularly noticeable when the animals were moved or excited. When they were caught and attempted to squeal, a faint wheeze was the only result. During quiet periods the cough was noticed only at intervals. All the animals showed a thick yellowish nasal discharge. The general condition was only fair, but none of the pigs were actually emaciated. The worst case was a gilt, which showed prolapse of the rectum as the result of straining. This animal was killed and examined, being brought back to the Laboratory for the purpose. The trachea, bronchi, and larger bronchioles contained a considerable quantity of mucus mixed with particles of food, the latter aspirated during the spasms of coughing. Bronchitis was evident. On examining the mucus microscopically, numerous oval worm eggs, measuring on an average 70 × 45 microns, and each containing an active embryo, were found. No free embryos were observed. The lungs certainly did not appear typically pneumonic. They showed no mottling, but small elevations were seen on the surface, and on palpation numerous small hard nodules about the size of a pea could be felt, particularly round the periphery, decreasing in number towards the body of the lungs. On incising one of these nodules it was found to consist of a mass of worms occupying and distending the bronchiole. The worms, varying in length from 1½ to 2 inches, were found to be female Metastrongylus apri. The lungs were then carefully dissected and it was found that by far the greater number of the parasites was present in the peripheral region of the organs, corresponding to the location of the nodules, though the worms were also present in parts of the lungs where no nodular formation was evident. In the larger bronchioles towards the centres of the lungs, one or two worms per bronchiole were found, but towards the periphery the bronchioles were packed with six or more, causing the distention and apparent nodular formation. The worms were surrounded with the tenacious yellow mucus, which was in some parts streaked with blood and also filled the bronchioles in which no worms were found. The total number of parasites found in both lungs was 210, and of these only twenty were males. It is worthy of note that in spite of a thorough examination of the mucus in the trachea and ramification of the bronchi, not one liberated embryo could be found, though eggs were numerous. The latter were found, however, only in the bronchi and their larger branches.

Some of the parasites were quite active. At first, in clearing one bronchiole, the writer laid each worm on the inside of an

opened bronchus until the next could be dislodged, but soon had to abandon this owing to the rapidity with which the parasites disappeared down the openings of the various branches of the bronchus.

On attempting to wash the worms in water they almost immediately (within about one minute) disintegrated, so warm physiological saline was substituted, in which they appeared quite lively and remained so for three days when kept in the incubator at 37°C.

Treatment.

Owing to the deep-seated location of the parasites, it was resolved to attempt treatment by means of the intra nasal injection of chloroform. First, however, fresh clean quarters were prepared and the old premises were disinfected and whitewashed. A week later, when these preparations were completed and the animals had been starved for twelve hours, another visit was paid. The three remaining pigs were coughing very badly even while at rest. They were reported to be still feeding well, but had noticeably lost condition. Each pig received 2 c.c. pure chloroform, 1 c.c. being dropped in each nostril with a hypodermic syringe minus the needle. After the administration the animals staggered about for a minute or so but soon recovered. As each was treated it was put in the new quarters. Treatment was repeated four days later, when it was noticed that the coughing had markedly diminished, which observation was confirmed—with emphasis—by the pigman. The squealing was, however, still very hoarse. One pig appeared to be suffering from some affection of the urinary organs, as it was persistently arching the back and straining, having apparently considerable difficulty in micturition. In this case also the cough was much less evident. Four days later, when another visit was paid, the cough had practically disappeared, and a slight improvement in condition was noticed. Treatment was repeated and there was no doubt whatever regarding improvement in squealing powers. Four days later the cough had quite disappeared, but it was decided to kill the pig which was showing signs of urinary trouble. On examination of the viscera, a cystic growth was found on the neck of the bladder. The lungs were perfectly normal and no trace whatever of worms was found in the whole respiratory tract.

It is interesting to note that the farmer from whom the pigs were bought stated that the two he retained from the litter showed no cough and " made splendid pigs ". None of the other pigs on that particular farm suffered from the parasites.

Case 2.

The second outbreak occurred in a herd of eighty-nine young pigs of about two months old. The history in this case was as follows :—

None of the pigs came from the same locality as in the last case, and none were coughing when purchased. All seemed to commence to cough about a week afterwards. Two died suddenly and were examined, distinct broncho-pneumonia being found in each case. The writer was called in the day after the last post mortem examination, and the cut lungs had been put aside overnight in a bucket of water for his inspection. From the husky nature of the cough, which was markedly increased on exercise, the nasal discharge, and general appearance of the animals, verminous pneumonia was suspected. A thorough examination of the lungs revealed the anterior half of a worm only, but on carefully examining the blood-stained water in the bucket, numerous disintegrated worms were discovered. The premises were then examined. The pigs spent most of their time in the open air, having the run of a large field—shelter consisting of disused cowsheds provided with a cement-floored run in front. Through the field there ran a shallow stream, which was actually the overflow from a spring farther up the slope. The stream simply lost itself in the centre of the field, the water spreading out on either side and making the ground marshy. Although the owner had never previously experienced this trouble among his pigs, which had always had the use of the field, he was advised to keep the present animals out of it or at least to fence off the marshy part.

To make diagnosis more certain the worst case in the herd was killed and examined. The lungs in this case were both pneumonic at the periphery, while there were pleuritic adhesions in the case of the left lung. Otherwise the examination produced exactly similar results as in Case 1, except that four female worms were found in the trachea itself. As the work of dislodging the parasites from the bronchioles by hand was very tedious and time could ill be spared, the following method was adopted :—the lungs were incised in several parts and placed in warm physiological saline in the incubator at 37°C. overnight. Next morning nearly all the worms had left the lungs and the majority were alive in the fluid. Only twelve were found in the lungs themselves, while 241 were removed from the saline. As in the former case, these lived for three days in saline at 37°C. In this case fourteen males only were found, while again no free embryos could be discovered in spite of careful examination.

The chloroform method of treatment was again adopted, though with some misgiving, as the weather this time (July) was at its hottest. The same dose, viz., 1 c.c. per nostril, was again given. This made the animals stagger and occasionally fall, but they soon recovered and there were no casualties. Treatment was repeated twice again at four day intervals. A slight improvement was noticed after one treatment only, while a week after the third treatment the cough was practically gone. The first sign of improvement was shown in the " squeal ", which at first was only a husky wheeze, but at the third treatment one became almost as hoarse as the pigs had been, through endeavours to make oneself heard above the noise. It was found in administering the chloroform that much time and material were wasted through the pigs refusing to allow the drug to be injected into the second nostril, so a double nozzle was made to the syringe, the " prongs " being about 1¼ inches apart. This was found to answer admirably and was used for the second and third treatments, much time and chloroform being saved by its use.

Two weeks after the third treatment the coughing had quite disappeared. The animals were kept out of the marshy field, and the houses and run had been thoroughly disinfected. About a month later, however, the writer was informed that the coughing had recommenced, and it was found that the pigs had been completely free from coughs for nearly three weeks when they had been again allowed access to the suspected field. Within a week the coughing again began.

The treatment was twice repeated and the field was again forbidden. Considerable improvement was noticed after two treatments only. Another treatment was contemplated, but in the meantime the owner was able to sell the animals. No pigs died from respiratory affections from the time the treatment was commenced, though a few died from intussusception of the gut and stoppage of the bowels. One only died from choking, while struggling during administration of the chloroform.

During the whole outbreak the animals showed a good appetite, except those which developed digestive troubles.

It would appear from the foregoing cases that :—

1. The time of year is of little importance in connection with outbreaks of infestation with Metastrongylus apri—the first case occurring in February, the second in July, with a recurrence in August.
2. Marshy ground is the most likely source of infection.
3. The parasites are situated in greatest numbers in the periphery of the lungs.

4. Females greatly predominate numerically over males.
5. Eggs do not appear to hatch in the respiratory tract.
6. Adult parasites are destroyed by immersion in water, but will emerge from the lungs and live for three days if these organs are placed in physiological saline at 37°C.
7. Chloroform administered intra-nasally in doses of 2 c.c. per pig—1 c.c. per nostril—by means of a double nozzled hypodermic syringe appears to be effective.
8. Three treatments at four day intervals are preferable.

Further Notes on Metastrongylus Apri.

Since the foregoing observations were carried out it has become apparent to the writer that the parasites are more widespread and are responsible for more loss among young pigs than has hitherto been supposed. The conditions of bronchitis and pneumonia are of course easily recognisable on post mortem, but one feels convinced that in many cases the actual cause of the condition, viz., the worms, has been overlooked, and this is probably the result of an unsystematic examination of the lungs. In several instances of outbreaks of obstinate pneumonia in pigs, the writer has received for examination half a lobe of the lung, i.e., the lung having been cut transversely through the middle. On opening the receptacle in which the specimen was contained female parasites have been found in large numbers, lying on the surface of the specimen, protruding from the cut bronchioles, and also in the bottom of the receptacle. As these parasites are about two inches in length and of respectable girth for lung worms it should be quite impossible for them to be overlooked and the reason of this oversight is most likely the fact that, as mentioned in the previous report, a considerable number of the worms are found towards the periphery of the lungs. In the cases of the specimens referred to, the parasites had emerged from their lairs during transit. If, instead of simply cutting into the substance of the lungs, the bronchi and bronchioles had been slit open in a systematic manner, there is no doubt whatever that the parasites would have been easily observed.

Evidence is accumulating to show that the chloroform method of treatment is proving remarkably effective *provided the condition* (of verminous broncho-pneumonia) *is recognised and the treatment adopted in time*—i.e., during the bronchitic stage, before the condition has proceeded too far into the pneumonic.

The example of one case which had gone too far may be mentioned. This pig after receiving the injection galloped out of

the building in which the operation was performed and forthwith died. On post mortem examination lobular pneumonia was very marked and from the bronchi and bronchioles 447 worms were removed, 293 being females and 154 males. Ninety per cent. of the males were found in the small bronchioles at the periphery of the lungs, where they were collected together in colonies by themselves quite apart from any females.

In the report of the original observations the proportion of males was stated to be much smaller than in this case and this was most probably due to lack of observation on the part of the writer, as the males, being of a brownish and semi-transparent appearance, besides being much smaller in every way than the females, are also much more difficult to see than the latter.

With regard to the treatment, much more rapid and effective results will be obtained if the affected animals are removed from the original houses, even if only to a rough shed in the next field, the shed, of course, being capable of disinfection. The contaminated houses appear to be the chief reason for the prolonged existence of the condition in a herd.

The difficulty of eradication of the parasites by natural agencies may be appreciated from the following experiments :—

Several worms from the case mentioned above were placed in ordinary tap water in a petri dish. Within a minute or two the parasites disintegrated and the ova escaped into the fluid. The ova were in various stages of development. The majority contained fully developed and lively embryos. In others the embryos were not mature while in the remainder segmentation had not commenced. In less than half an hour at room temperature a considerable number of the eggs containing mature larvae had hatched—the larva after twisting and turning for some time and repeatedly butting the egg " shell " with its anterior end, finally rupturing the shell and shooting forth into the surrounding fluid.

Within forty-eight hours all mature larvae had emerged from their respective eggs. They were quite active and became more so as the external temperature was raised by means of a lighted Bunsen burner placed near the edge of the petri dish containing them.

When they were examined next morning they were all motionless. The night had been frosty and the temperature of the air in the laboratory had been as low as 34°F. When a Bunsen burner was lit and placed near the microscope the majority of the larvae again became active.

The petri dish containing the larvae in water was then placed outside in the open air. The depth of water in the petri dish was about 1/16th of an inch. Next morning it was found that the temperature had fallen to 6° below freezing point and the water in the petri dish was frozen solid. The dish and its contents was then placed in the incubator at 37°C. and the contents thawed. On examination, the majority of the larvae were again found to be as active as ever, although some remained motionless in spite of the raised temperature of their surroundings.

The larvae were divided into two groups—the first remaining in the original water while the water in the second group was changed daily. Those in Group 1 were apparently all dead in one month, while those in Group 2 remained alive for three months. A comparatively weak solution of common salt was found to be most effective in destroying both larvae and the eggs.

It is hoped to carry out further experiments with regard to the control of the parasites, but it may be mentioned here that various other lethal agents which were tried, while they destroyed the hatched larvae, were apparently useless, or took a comparatively long time in destroying the ova. The salt solution, however, caused both larvae and ova to shrivel up within five minutes.

Some authors state that the larvae will survive desiccation and will become re-animated when once more exposed to moisture. The writer has been unable to prove the truth of this assertion.

FARM POULTRY KEEPING.

By Professor Willard C. Thompson, B.Sc.,
Director, National Institute of Poultry Husbandry.

A very large proportion of the country's total annual egg and poultry production comes from the mass of relatively small poultry flocks which are being kept on the general farms of England and Wales. It probably will always be so. The farm poultry flock must remain the great source of supply of eggs and poultry. The future holds forth every reason why the farm poultry keeper should rest assured that there will be abundant market for his eggs and poultry products, if they are of suitable quality. The success of the farm poultry flock as a national enterprise, or as a private unit of any farm in the future, must depend very largely upon the success with which farmers are able to cut down the actual costs of poultry and egg production. It is unlikely that, except in certain places, there will be any very

great increase in prices paid to farmers for their eggs and poultry products over those they are now receiving. And yet farmers must be assured of a reasonable profit on their poultry operations if the country is to expect them to keep up that type of food production. This being the case the margin between cost of poultry and egg production on the farm and the final sales prices realised for those products must be widened, and a reasonable profit made largely by means of lowering the former figure, the costs of production. This will be done largely by (1) improving the average grade of the farm poultry flock by breeding and selection, (2) by recognising the fundamental importance of housing the farm flock adequately and efficiently, (3) by feeding useful and balanced rations, and (4) by taking care of every possible item which might be made to contribute to the total success.

The Poultry House.

The laying hen is a creature of environment in many respects. Winter egg production, which is the goal of every commercial poultryman, and should be the aim of every farm poultry keeper, is particularly the result of careful attention to the environment with which laying fowls are surrounded. It is scarcely possible to imagine that any poultry keeper will be successful in securing winter egg production unless he gives most careful attention to the poultry house, the surroundings with which he furnishes his hens, and the daily care and management of that house. One reason, undoubtedly, why many a farm poultry keeper has not enjoyed anything like a profitable winter egg production may often be found in a failure on his part to provide the sort of environment which will induce his hens to lay eggs in spite of outside weather conditions. Egg production during the cold months of the winter is not a natural function, but rather a forced one. The poultry keeper must try to make up by the efficiency of his poultry house the disadvantages created by winter weather conditions. By proper housing he must attempt to surround the birds with an environment which will induce increased food consumption and an egg production similar to that which more or less naturally occurs during spring months.

One of the first problems undertaken by the National Institute of Poultry Husbandry during the past year was the study of a suitable type of farm poultry house. In entering into that study several things were kept clearly in mind. In the first place it was appreciated that the cost of the average farm poultry house must be kept down as low as might be possible without sacrificing efficiency and stability of the house. The farm poultry

house which has been planned and built at the Institute can be built in a number of different ways, so that it may be constructed to suit varying financial resources. Of course it must be remembered that when the various cuts suggested are made, some effect is bound to be felt upon the life-time of the house, its general efficiency, and its ability to meet fullest requirements. In the second place, a farm poultry house should preferably be simple in design and type of construction so that if necessary, or if desired, it may be home-built. In the third place, it must be compact and not elaborate, providing economically for the maximum farm poultry flock which will probably be desired by the average farmer. In the fourth place, it must be durable and made in such a manner as to retain its usefulness throughout a comparatively long period without suffering too great a depreciation each year, or requiring too many repairs each season.

This farm poultry house is built to incorporate certain simple principles. Firstly, it is built upon the readily proven premise that a square building is the cheapest and most economical means of covering a given area and, in poultry housing, the most efficient means of providing house-space for a given flock of fowls. This principle of providing a square house for fowls is an important one, especially when the number of houses to be built becomes large, as it may do on a commercial poultry plant. Also, it should be remembered that the multiple unit house, which is most economical, can best be constructed by the use of the square-pen idea. Secondly, this house incorporates the general principle of providing an open floor space, all of which is available for the use of the fowls at all times, and particularly during those winter days when weather conditions outside make it highly advisable that the fowls be retained within their houses. Thirdly, this house further incorporates the general principle of movable fixtures, such as nests, dropping boards, perches, food hoppers, water supply, etc., thus rendering the house not only capable of complete sanitation, but also capable of rapid re-arrangement and re-adjustment for possible use for other purposes than strictly as a house for laying birds. Fourthly, this house embodies a type of construction designed to provide maximum comfort to the fowls, both in the winter and summer periods. This feature is accomplished by means of the straw loft, which holds an even temperature day in and day out, either in summer or winter, more nearly than any other types of construction which have been offered or tried in this country. The straw loft, as will be pointed out later in detail, also affects the general dryness of the house. Fifthly, this house is built upon the principle that it is preferable,

other things being equal, to provide an evenly lighted house, with windows in all four walls. Sixthly, this house includes within its arrangement means of encouraging the production of eggs in clean condition and with a minimum of breakage, this feature being emphasised by the nature and the location of the nests.

Whether or not a farmer or poultryman may desire to follow this particular design of farm poultry house is more or less immaterial. It is, however, important that anyone desiring a long house of this type should attempt to embody within it all of these principles just mentioned. An attempt has been made to include them in this particular type of house in such a manner as to accomplish it at least possible expense, and with the greatest possible satisfaction.

Size of House.

The actual farm poultry house which has been erected at the Experimental Farm of the National Institute of Poultry Husbandry is 25′ × 25′ in size, thus providing 625 square feet of floor space.[1] A house of this size provides ample space for approximately 150 laying or breeding hens, and the requisite number of male birds which should be carried with that flock, that is, approximately fifteen. This particular size has been chosen for the model to be used, largely because considered opinion has often indicated that the average farm flock might very economically and practically be composed of approximately 150 hens, a useful and satisfactory size of flock for the conditions under which it will ordinarily be kept and managed.

It is suggested that any farm poultry flock owner desiring to use this general style of poultry house could build it, incorporating all of the general principles, and varying, chiefly, only in actual size.

The following suggestions of modifications might be found practical and, under certain circumstances, preferable to the 150-hen size :—

(1) The farm poultry house, 20′ × 20′ in size, providing 400 square feet of floor space and furnishing adequate room for a farm flock of approximately 100 fowls. The same general plan can be followed in this case, where a cut of five feet on each wall is suggested. The alterations might be as follows :—(*a*) Change the width of the front or south wall windows by omitting one vertical row of panes, thus leaving four vertical rows of panes in each front window instead of five. Further, if thought desirable, the width of the front door might be made 2′ 6″, or possibly 3′,

[1] An illustration of this house is shown on the front cover of the *Journal of the National Poultry Institute*, Vol. 11, No. 2.

instead of 3′ 6″. (*b*) Windows in every side wall or rear wall could remain the same. (*c*) In all other particulars the same plan can be used for the 20′ × 20′ model. (*d*) Possibly in this shorter house, it might be feasible to use a 3″ × 2″ framework instead of a 4″ × 2″ framework as is considered necessary for the larger area.

(2) Another modification of this same type of house might be one measuring 30′ × 30′, providing 900 square feet of floor space, which will provide adequate accommodation for a farm flock of approximately 225 to 250 fowls. In using this increased size the following suggestions might be found useful :—(*a*) Do not use less than a 4″ × 2″ framing. (*b*) Place double the amount of window space in either side wall, also possibly in the rear wall. (*c*) Use exactly the same door and window space in the front or south wall as for the 25′ × 25′ size. It is suggested that, as in the other case, the windows should be centred in the respective places to the left and to the right of the central front door.

Principles of Poultry Feeding.

In looking over the figures which express the results of a year's poultry feeding and management, the poultryman must ascertain some very definite information if he would plan out a better scheme and a cheaper and more economical method for the following season. In the first place, he must recall and never lose sight of the important fact that the efficient and adequate laying ration must consist of two essential parts, a grain mixture and a mash mixture. The efficient poultry feeder, whose purpose in feeding is economical egg production, realizes that his hens must be furnished with food materials : *Firstly*, for the purpose of maintaining their bodies in full health, condition, and fitness, and supplying the energy essential to the increased body processes and operations that are brought into play by forcing for egg production; *Secondly*, for the definite object of stimulating and bringing about the actual formation and production of a greatly increased number of eggs. Feeding for the latter objective is useless unless feeding for the first purpose, maintenance and energy, is carefully done. As the poultry man looks forward during late summer weeks to the fall days when the laying pens will be made up for the forthcoming egg laying season, his first thoughts should be directed toward the matter of properly, economically and cheaply furnishing the prospective layers with maintenance rations.

The new pullet, just about to reach egg-laying maturity, must enter that new period of her life fitly prepared, or

" finished ", for the job of using egg-forcing foods in the economical formation of eggs. The pullets, to reach laying stage in this proper condition of flesh and reserve of fat, must be watched carefully as autumn days approach, as their combs begin to redden, and their bodies begin to take on that adult form and appearance which indicates an early start in egg production. The grain ration, which will later be looked upon as chiefly the maintenance and energy-providing part of the daily diet, must also be considered the part of the autumn feeding schedule which will primarily be effective in getting pullets into the desired state of " finish ". There is scarcely good reason why essentially the same sort of grain mixture which will be used for the layers in full laying condition will not be useful for obtaining " finish " in the pullets. At the National Poultry Institute it has been found quite possible and economical to use the same mixture in each case. Amounts fed must be determined by the condition of the pullets. If the pullets are a bit thin in flesh, as found by handling, it is an easy matter to begin increasing the amounts of grain mixture allowed. Probably the average lot of pullets will require something like eleven to twelve pounds of grain mixture per day per hundred to get them into proper condition in which to start the long season of egg production ahead of them. This amount is suggested, providing that those eleven or twelve pounds consist of a balanced mixture of digestible nutrients, such as will most economically provide the needed food elements. Happily, in the experience of the Institute at least, the requirements of such " finishing " pullets and the requirements of the same pullets after they have commenced laying, so far as grain ration is concerned, are practically identical.

Of course it is not certain that the ideal ration and the ideal balance of nutritive requirements have been worked out as yet. It will take years of great effort on the part of many investigators to find the last fact and to determine the last principle in this subject. But the experience of this Institute in this matter can be suggested, namely, that the grain mixture used for " finishing " pullets and for supplying maintenance and energy requirements of layers should furnish approximately 25.87 lb. of digestible crude protein (that is, digestible by the hen) to every 170.72 lb. of digestible carbohydrates and 8.10 lb. of digestible fats. This balance gives a nutritive ratio of 1 : 7.8, which is to say that to every pound of digestible crude protein furnished by this mixture 7.8 lb. of digestible carbohydrates and fats taken together are supplied.[2] At times, when flocks of pullets are

[2] By multiplying total digestible fat content by 2.25 the said fats are reduced to same terms as carbohydrates and thus can be added to same.

decidedly under weight, or when weather conditions are severe and the temperature very low, it may be necessary to slightly widen even this already wide balance, by providing a somewhat higher proportion of digestible carbohydrates and fats, making the nutritive ratio 1 : 7.8 instead of 1 : 7.3, as just stated. The essential and important thing is to provide these digestible nutrients in something like this balance or order. Different poultrymen may make varying grain mixtures to obtain this balance, for there are several conceivable mixtures which would provide practically the very amounts and balance of digestible nutrients mentioned.

It is absolutely fundamental that the practical poultry feeders should know what balance of really digested food nutrients his layers must have in order to produce eggs at a profit, and, at that, the greatest possible profit. If he has this information he can set to work to provide those requirements by the grain mixture which will most economically furnish them in his locality. Prices of foodstuffs vary widely from place to place and some things are available easily in one locality and are not procurable in others. The poultry feeder should be somewhat free to vary his actual mixtures, and so he may if he always provides at least approximately the needs of his hens. Under the circumstances of the National Poultry Institute, in the Midlands of England, the conclusion is being reached that equal parts, by weight, of wheat, oats, and maize can be mixed together, and will provide a grain ration which meets the balanced requirements just mentioned, and that by adding an extra part of maize to the other mixture, the grain ration with a nutritive ratio of 1 : 7.8 is secured. So long as the grains used in any grain mixture are palatable to the fowls, available, and reasonably cheap, there is no apparent reason why the mixture should not be varied from time to time. The poultryman might change his mixture formula every once in a while, if changing conditions might enable him to make a considerable saving by so varying the formula in order to take advantage of fluctuating prices of foodstuffs, providing he could do so without appreciably altering the digestible nutrient balance and total. As a matter of fact, there is some evidence to indicate that fowls do not object to a bit of variety from time to time, even though they are constantly referred to as creatures of habit.

There is just another word about the grain ration which should be said. The Institute has found that for the average flock of pullet layers, especially of the lighter breeds, the amounts of grain ration to be allowed might be put down with something like the definiteness of rules. For the average flock, allow ten to

twelve pounds of grain ration per day per hundred fowls during those months in the early part of the laying year, October, November, December, January, February, March, April; reduce by a couple of pounds per day per hundred hens as soon as May is reached, and drop another pound or two with the oncoming of the two late summer months, September and October. A range is suggested as, for example, ten to twelve lb., for no feeder should be so bound down by a hard and fast rule that he cannot vary it according to the condition and apparent needs of the fowls, and in order always to avoid waste. Good sense or judgment is as essential as the feed pail in poultry feeding.

Mash Ration Requirements.

The mash previously used at Harper Adams College was studied and it was found that, while it had produced eggs, those eggs had cost too much money, thus keeping the margin of actual profit down to too low a figure. Some poultry farmers will not feed a certain food material because of its cost per hundredweight, but it must be said that the price per hundredweight of foodstuffs for poultry feeding is an unimportant figure, comparatively speaking. The figure of greatest importance is the cost of producing a dozen of eggs at any given time. Any sort of food, no matter how great its cost per hundredweight can and should be used providing it lowers the cost of egg production and gives a wider margin between what will be received for those eggs and what it actually cost to produce them. When the poultry raiser sets out to consider the egg-producing side of the ration, which every one is quite willing to admit is the mash mixture part of the daily food allowance, it is essential and particularly important that the feeder should have a more or less accurate idea, limited only be the incompleteness of present day knowledge on the subject, as to the actual and real requirements of his hens and as to food nutrients which will induce and stimulate egg production beyond natural inclination and behaviour. The staff of the National Institute have worked on the premise that experimental and practical experience up to date have determined the balance of digestible nutrients which laying hens demand for efficient egg production. This set of figures is derived from an analysis of the best data available on the subject. Working it out in practical terms, it is found that layers require a balance which is essentially 101.14 lb. of digestible crude protein to every 210.33 lb. of digestible carbohydrates and 28.05 lb. digestible fats. This balance gives a nutritive ratio of 1 : 2.58, or a rather narrow ratio, a proportion of one part of protein to a bit over two and one-half

parts of carbohydrates and fats taken together. There may not be complete agreement on the figures which express this balance, but in the experience of the Institute they do hold to be apparently true, as expressing at least a profit-making and egg-producing balance of digestible food nutrients. They furnish the first and most essential factor to be considered in the formation of a suitable and commercially successful mash ration for inducing and stimulating economical egg production. Again, as in the case of the grain ration, each farmer can furnish these basically essential food nutrients by any mixture which the prices on his local feed market may indicate as being the cheaper means of supplying these needed digestible nutrients.

In England there are available in most places where poultry foodstuffs are being bought two most excellent nutrient-bearing materials which have been and are being used widely for poultry feeding. These are Sussex Ground Oats and Alfalfa Meal, both splendid feeding stuffs, supplying much of what hens need. But the local prices for these two products have been rather on the high side of recent months, and the price is important. When the rations which had been used at the College were reviewed, one of the first items that commanded attention was a charge of something like 18s. 9d. per hundredweight for Sussex Ground Oats, and over 14s. for Alfalfa Meal. These prices are considered high, probably two or three shillings higher than one can afford to pay for poultry foods. Their value or usefulness was not questioned, but it was necessary to consider their prices. A calculation was made to see if there was some way of furnishing the total amounts and balance of digestible food nutrients which were wanted for the layers without using these rather high priced foodstuffs. It is very easy to make out a mash ration by using these prettily balanced foods, for they are useful and fowls like them and do well on them. It is not impossible to furnish a mash mixture which will present the same totals and balance without using either of them. So a mixture which was the result of hours of figuring was tried, and was used for several large laying flocks during the past year. It has consisted of two hundred lb. of wheat bran, two hundred lb. of maize-meal, one hundred lb. of best middlings, and one hundred lb. meatmeal of 50—60% protein. If the known poultry-digestible nutrients in these amounts are set down they will be found to meet the total and balance of requirements rather closely. In September, 1926, the wheat bran was costing the Institute 6s., the best middlings 7s. 6d., the maize-meal 9s. 10d., and meatmeal 17s. per hundredweight. It is useful to set down the actual cost prices of these

various foodstuffs used, figuring out the exact cost per pound of the final mash mixture at any time that a new lot is purchased, as this cost figure is useful and essential as a guide. If the cost of the above ration is calculated it will be found to be one penny per pound approximately. That is not a bad price per pound to pay for an egg-producing mash. On that particular mash the Institute made its best winter egg records and best year-total records, and clearly its best profits. This mash may be recommended for careful consideration. It has worked well indeed for the Institute, and at times the cost has been even lower than it was in September, 1926.

Allow the layers free access to the mash. The dry mash system has been preferred at the Institute, but it does not matter much if another poultryman prefers the moist mash. The point is to get the fowls to eat the mash, about twelve pounds per hundred layers and all will be well.

A TRIAL OF FIRST EARLY PEAS.

By Geo. H. Copley, N.D.H.,

Horticultural Superintendent for Glamorgan.

The garden pea (*Pisum sativum*) is a very important item in the programme of commercial horticulture. In its season, which may be said to extend from the beginning of the third week in June until the end of the second week in August, it practically holds the field. During that period the purchasing public care for little else in the way of vegetables. Recognising this, the Glamorgan Agricultural Committee decided to conduct a variety trial of first early peas in the garden attached to the County Demonstration Farm at Pencoed. The objects of the trial were :—

(1) To test the cropping capacity of the varieties grown.
(2) To note the ability of each variety to " fill " its pods.
(3) To note the time taken to mature.

The following sixteen varieties were included in the trial :—

Leader.	Premium Gem.
Express.	Satisfaction.
Witham Wonder.	Pioneer.
Mayflower.	Hundredfold.
Reading Wonder.	Excelsior.
Early Superb.	Harbinger.
Daffodil.	Green Gem.
Marvellous.	King Edward VII.

None of these varieties exceeds two feet in height, and it is therefore unnecessary to stake them. The soil at the County

Demonstration Farm is a medium well-drained loam, and the garden lies in a sheltered position. Metereological conditions being favourable it was decided to sow the seed on the 19th March, in land which had been thoroughly dug to the depth of one spit and dressed with farmyard manure at the rate of twenty-four tons per acre. Trenches four inches deep and nine inches wide were made at distances of two feet. Four rows of seed were deposited in each trench, each seed being given an all-round distance of three inches for development. Before the seed was covered a dressing of superphosphate (30%) was applied at the rate of three-quarters of an ounce per lineal yard of drill, with the object of stimulating the development of roots. An excellent germination followed, the only variety proving an exception in this respect being Witham Wonder. Seventy-three per cent. only of the seed of this variety appeared above ground. When the plants had attained the height of three inches they were plied with sulphate of ammonia at the rate of half an ounce per yard run of drill, in order to stimulate vigorous leaf formation, and the crop gave a ready response. This is a cultural operation which might with advantage be more frequently adopted by commercial growers. Growth proceeded satisfactorily until the crop was fit for picking. The plants showed no signs of being affected by the drought in early June, thanks to the good texture of the ground and the substantial dressing of farmyard manure which they had received. The first picking was made on 16th June, and for the purpose of comparison a unit row-length of twenty-four feet was selected for weighing. The peas were weighed in the pods in accordance with commercial practice. The second and last picking was made on 26th June.

The following table gives the results :—

Variety.	*Weight in lb. 16th June.*	*Weight in lb. 26th June.*	*Total lb.*
Excelsior ...	21	5½	26½
Harbinger ...	18	4	22
Green Gem ...	15	5	20
Witham Wonder ...	12	3	15
Express ...	12	4½	16½
Leader ...	11	8½	19½
Pioneer ...	13	12½	25½
Hundredfold ...	10	8	18
Mayflower ...	6	7	13
Satisfaction ...	6	6½	12½
Premium Gem ...	4½	17	21½
King Edward VII ...	2	9	11
Marvellous ...	1	8½	9½
Daffodil ...	—	8½	8½
Early Superb ...	—	7½	7½
Reading Wonder ..	—	6½	6½

These results reveal a fairly wide variation in yield. All but the last four varieties in the list may be said to have justified themselves for commercial cultivation on the score of yield. The variety King Edward VII, the poorest cropper of the twelve, with its elven pounds per twenty-four feet run of drill, gave a yield at the rate of two hundred bushels per acre, which would have enabled a fair profit to be made. A most important point in connection with trials of this type, however, is the date of maturing. The first five varieties in the table had considerably more than half their crop ready for market on the 19th June. During the week ended 21st June the average wholesale price for garden peas on the Cardiff market was 7d. to 8d. per lb. The remaining seven varieties showed a balance on the other side, in some instances a heavy one. During the week ended 28th June, when these varieties were placed on the market in bulk, the price at Cardiff was 4d. to 6d. per lb. Consequently, the varieties yielding the most handsome profit were those which first reached maturity. Bearing this in mind it is clear that in this trial the varieties Excelsior, Harbinger, Green Gem, Witham Wonder and Express carried off the honours. In order to express the ability of each variety to "fill" its pod twenty-four pods of each variety were opened and examined. With the exception of Daffodil and King Edward VII every variety "filled" well. The blank spaces noted in the pods were so rare that they could not be cited in evidence against the varieties concerned, and in each instance the seeds pressed fairly closely to the sutures of the pod. The process of fertilisation appears to have been completely successful in the variety Daffodil, but the seeds never more than half filled the pod. Twelve pods of this variety were allowed to ripen and the result confirmed the opinion already formed. The process of fertilisation would not appear to have run full tilt in the variety King Edward VII. The twenty-four pods examined should have accommodated one hundred and seventy-five seeds, but only one hundred and thirty-nine could be counted. The thirty-six ovules counted as failures were no larger than the point of a pin when the fertilised seeds were at their full size.

First early peas are not often attacked by fungoid diseases, and in this trial immunity was secured, save in the case of the variety Premium Gem, which developed a trace of mildew.

MANURIAL AND STRIPE DISEASE CONTROL EXPERIMENT ON TOMATOES, RHYL.

By H. L. Jones, N.D.H.,
Horticultural Superintendent for Flintshire.

The following experiment was undertaken by the expressed wish of the market growers of tomatoes with a view to testing and proving what was the best method of controlling stripe disease, which has been very troublesome in the district, and also with a view to testing the best methods of manuring. The method of manuring was supposed to be a predisposing cause of the disease called *Stripe*, and the present results seem to support that view.

The experiment was at all times open to inspection by the growers in the district and to any other grower on giving a few days' notice to the proprietor of the nursery, and it is of interest to record that commercial growers in the district availed themselves of the offer. They visited the greenhouse where the experiment was being conducted at various dates throughout the season, and it is clear that the results have been of value to them.

It is only fair to say that the growers had very little faith in the experiment, and the proprietor of the nursery had changed the soil in all his other houses, which must have been a very expensive thing to him. The border where the experiment was conducted was left unchanged, and it was on this border that the plants had been attacked worst of all during the previous year.

It was not a season when one would expect the disease to be very prevalent; yet, even where the soil had been changed, the disease was found on the plants—in some cases rather badly, and generally much worse than on any part of the border where the plants had been treated. The growers have been convinced of the value of lime and the danger of applying heavy dressings of organic manures, and of top dressing the plants with heavy dressings of nitrogenous manures during growth, which without doubt was the cause of the losses from this disease.

It has been conclusively proved that potash reduces the disease if it does not entirely eliminate it, as no trace of the disease was found where potash had been applied, as in treatment II and IV.

This experiment was conducted in conjunction with Dr. Bewley, of the Cheshunt Experimental Station, Cheshunt, Herts, and the manurial base treatment given was at his suggestion.

Results of the Experiment.

The number of plants in each section of treatment was twelve.

Base treatment I, per square yard.	*Prevalence of the disease.*	*Weight.*
1lb. of Lime 14lb. of Stable Manure ¼lb. of Bone Meal ¼lb. of Bone Flour ¼lb. of Hoof and Horn Meal ¼lb. of Sulphate of Potash	One plant slightly affected with stripe, but grew out of it.	75lbs.

Top dressing every fourteen days after the second truss had formed with the following mixture at the rate of 2oz. per sq. yd. :—

Three parts by weight of Sulphate of Ammonia.
Two parts by weight of Dried Blood.
Seven parts by weight of Superphosphate of Lime (30% phosphate).
Five parts by weight of Pure Dissolved Bones.
Half-a-part by weight of Bone Flour.
Two-and-a-half parts by weight of Sulphate of Potash.

Base treatment II, per square yard.	*Prevalence of the disease.*	*Weight.*
1lb. of Lime 14lb. of Stable Manure ¼lb. of Bone Meal ¼lb. of Bone Flour ¼lb. of Sulphate of Potash	No trace of disease.	66½lbs.

Top dressing applied as above in No. 1, but replaced during the middle of May by Sulphate of Potash at the rate of 2oz. per square yard.

Base treatment III, per square yard.	*Prevalence of the disease.*	*Weight.*
1lb. of Lime 14lb. of Stable Manure ¼lb. of Bone Meal ¼lb of Bone Flour ½lb. of Sulphate of Potash	Trace of the disease in several plants, but not serious.	55lbs.

Top dressing as in No. 1 treatment.

Treatment IV, per square yard.	*Prevalence of the disease.*	*Weight.*
The same treatment as in III, but top dressing as in treatment II.	No trace of the disease.	68¼lbs.

Base treatment V, per square yard.	*Prevalence of the disease.*	*Weight.*
14lb. of Stable Manure 1lb. of Superphosphate (30% phosphate). Top dressing with a Nitrogenous Manure, either Nitrate of Soda or Sulphate of Ammonia, 1oz. to the square yard, after the second truss had formed, alternately with a Compound Manure.	There were several plants on this plot very badly affected with the disease, and they actually died early in the season, which reduced the yield of this section.	41¼lbs.

The treatment in Section V is the usual treatment given in the district.

WINTER SPRAYING OF FRUIT TREES WITH CARBOLINEUM WASHES.

By Harry L. Jones, N.D.H.,
Horticultural Superintendent for Flintshire.

It is understood by all growers of fruit that it is necessary to keep their trees free from moss, lichen, insect pests and fungoid diseases if they are able to make satisfactory growth and to produce profitable crops of fruit.

Until recently the only cleansing or dormant washes recommended were caustic soda, lime sulphur and lime wash, and although all these did certainly clear the trunk and branches of moss and lichen, their effect on the eggs of insects and mussel scale was very slight, and at best seldom gave anything like effective control.

During the last few years we have heard much of winter washes made of tar oil, tar distillate or tar derivatives, and claims have been made for these that they give absolute and complete control of such insects as apple sucker, aphides, scale insects, and to a great extent the larvae of winter moths and other caterpillars. In addition to the control of these pests, it is claimed that these newer washes free the trees of moss and lichen.

In order to obtain trustworthy information as to the relative efficacy of some of the chief brands that are on the market, and to discover their suitability for use in North Wales, it was decided to test a number of the proprietary washes. With that end in view several of the firms which advertise in the horticultural press were approached, and Messrs. Murphy & Sons, of Mortlake, London, S.W., the manufacturers of "Mortegg," and Messrs. Craven & Co., of Evesham, the manufacturers of "Carbo-Craven," Mr. Van der Linden, St. Mary's Chambers, The Strand, London, the importers of "Carbokrimp," and another firm, whose special wash is in this article referred to as No. 4, very kindly offered to supply the writer with sufficient of their washes to spray at least 100 trees. It was decided to conduct the experiments in orchards at the following centres:—St. Asaph, Flintshire; Caerwys, Flintshire; Mold, Flintshire; and one in the detached portion of the county at Hanmer; at Bangor and Llanrug in the county of Caernarvon. Other orchards were treated, but as such trees were sprayed without any supervision the result as far as these notes are concerned are ignored.

The trees were sprayed at each centre, with one exception, by the second week in January. At one centre, owing to circumstances which could not be avoided, the trees were not sprayed until the 17th February, the owner being warned that damage to the trees might result from the application of the spray so late in the season. As, however, he was anxious to find out whether it was possible to control plum aphis he decided to have some of the trees sprayed, leaving the remainder as controls. At each of the other centres a number of trees were likewise left unsprayed for this purpose. At each of the centres chosen the trees had been very severely attacked by various pests in previous years.

At Caerwys apples and gooseberries only were sprayed; at Cilcen Hall, Mold, pears, apples, plums and peaches; at St. Asaph, apples, pears, peaches, plums, cherries and apricots; at Hanmer plums and apples only were sprayed; and at Bangor and Llanrug apples only were sprayed. At each centre the wash was applied at 7½% concentration.

The reports on the plots were examined by Dr. C. L. Walton and the writer and are as follows :—

Flintshire.

Plas-yn-Cwm, St. Asaph.

Elevation, 250 feet. Spray used, No. 4. Spray applied January 1st, 1926; inspected April 26th, 1926. Forty-four wall trees, plums, cordon apples and pears, peaches, cherries and apricot; 100 bush trees in grass orchard and fifty gooseberries; whilst thirty trees in all were left unsprayed as controls.

Insects :—Infestation on plums had been severe in 1925. At examination the sprayed trees showed considerable improvement, but several had up to 5%—10% of leaves rolled by *A. prunina.* Controls had 50%—60% leaves affected.

Apples.—Considerable number of *Aphides, Anuraphis roseus malifolia,* etc., were present. Unsprayed very badly infested; larvae and nymphs of two species very common. No *Psylla mali* seen on sprayed trees, but present on the controls in numbers.

On gooseberries *Pteronidia ribesii* was hatching on both sprayed and unsprayed bushes.

Peaches very badly infested and leaves curled on sprayed and unsprayed trees.

Tortrix larvae were common on all varieties, both treated and untreated. Winter moths' larvae were very common on sprayed and unsprayed trees.

General inference.—Result fair; controlled psylla but not aphis.

C.C. Demonstration Orchard, Wernfawr, Caerwys.

Elevation, 600-650 feet. " Mortegg " applied January 12th, 1926; inspected April 26th and June 8th, 1926.

Sixty young apple trees and six plums were sprayed, one of each variety being left as controls. One hundred and twenty gooseberries, and six left as controls. Orchard very badly infested with aphides in 1924-25.

Apples.—A few aphides were present on one or two trees at first visit. Psylla : None seen on sprayed trees, several seen on controls. Winter moth larvae numerous on all trees both sprayed and unsprayed.

This orchard was late and a second inspection was made on June 8th.

Apples.—Only one or two aphides were seen on the sprayed trees; the unsprayed were rather badly infested, and after a lead arsenate spray the trees were making clean and vigorous growth.

Gooseberries.—Were making clean and vigorous growth.

Plums.—A few leaves were curled by *A. prunina.*

General impression.—Good.

Cilcain Hall, near Mold.

Elevation, 700 feet. " Carbo-Craven " applied January 14th, 1926; inspected April 26th, 1926. Trees sprayed, sixty, including apples, pears, plums, peaches and gooseberries.

Apples.—A few aphides present. Controls badly infested with aphides. Psylla : Only one nymph was seen after careful search; the controls were severely attacked.

Plums.—*Anuraphis prunina* fairly common on sprayed and very severe on unsprayed trees.

Peaches.—A few leaves curled by aphides, while the controls were severely attacked.

Gooseberries.—Clean and making vigorous growth. Controls severely attacked by aphides.

General inference.—Result very fair.

Maelor District, Credington Gates, Hanmer, near Whitchurch.

Elevation, 300 feet. Spray applied, " Carbokrimp," February 17th, 1926. Severe aphis infestation since early 1918. Trees sprayed : Forty cordon plums (all on walls), including Czar, Greengage, Pershore (yellow and black), Victoria and Monarch. Ten apple trees were also treated, and a number, as before stated, were left as controls. Examined on June 7th, 1926.

All the plums were perfectly clean with the exception of a few winged aphides on the top of three Pershore plums; this

was undoubtedly due to migration from nearby unsprayed trees. Controls: 80%—90% of the leaves on the plum trees left as controls were curled up and ruined by *prunina.*

Apples sprayed same date: Bramley Seedling, Blenheim Orange, Lord's Grosvenor, Lord Derby and Chas Ross. No psylla or aphis present.

General inference. — The plums and apples have made vigorous, clean and healthy growth, but, owing to the late application of the spray, the flower buds had been damaged on the plums and very few fruit had set in consequence. The apples had not suffered from the late application of the spray, and they were carrying a good crop. Apart from the plums suffering from the late application of the spray the result here was a complete control of aphides, psylla and winter moths.

Caernarvonshire.

Orchard at Lloyd's Bank, Bangor.

Elevation 80 feet. Sprayed with "Carbokrimp" on January 14th, 1926, by Mr. John Roberts, Horticultural Superintendent for Caernarvonshire. Trees sprayed: Thirty apples. *Anuraphis craetagi* was very severe in 1925. At the time the trees were sprayed mussel scale, woolly aphis and the eggs of aphides were very prominent on the trees. Examined May 10th, 1926.

Twelve of the trees were free from aphides and psylla, and all the mussel scale seemed dead. The remainder of the trees had a few aphides, and the typical red-galled leaves showed here and there, the average being five leaves per tree. Woolly aphis had not diminished to any great extent, if any. The controls were severely infested with all the pests mentioned above.

General inference.—Fairly satisfactory and a great improvement.

Pontrug.

Walled garden, elevation 500 feet, and a rather exposed situation. Trees sprayed January 14th, 1926; inspected May 10th.

Twenty apple trees were sprayed. Trees clean when examined, and making vigorous growth. Controls: Aphides and psylla present in great numbers.

General impression.—Very good.

Conclusions.

The carbolineum winter washes are most certainly a great advance on any winter wash the writer has hitherto used, in some cases a single spraying effecting control of such pests as

leaf-curling aphis, psylla and also mussel scale. Control of winter moth and other larva cannot be relied upon. Although the application of the spray at Credington Gates resulted in a complete control, it must be understood that such a late application of the spray is not recommended, and the trees must be absolutely dormant when the spray is applied or damage to the buds may happen. For the control of winter moths it is recommended to spray the trees with lead arsenate after the blossom falls at the rate of 1lb. to 20 gallons of water, whilst in the case of standard trees grease banding is also recommended.

In all cases the various sprays were applied at 7½% concentration, but the writer believes that it is possible to apply concentrations up to 10% on apples and plums if this is done when the trees are absolutely dormant. Plums should not be sprayed if there are any signs that the buds are breaking; to do so is to court failure, as it will undoubtedly cause failure.

All brands of carbolineum washes do not give equally good results, or at least do not give perfect control of insect pests. All of them cleanse the trees of lichen and moss, and as far as can be seen no harm was done to the trees sprayed, as all those sprayed appeared to make a far more vigorous growth than the controls.

Before applying any of these sprays it is advisable to seek the advice and help of the horticultural offieer of the county, who will give advice as to the most suitable brand for use and the concentration to apply.

I should like to thank Dr. C. L. Walton, the Adviser in Zoology at the University College of North Wales, Bangor, for his assistance and help in identifying the various insects, etc., and Mr. John Roberts, the Horticultural Superintendent to the Caernarvonshire Education Committee, for his kind assistance and advice.

ABSTRACTS, REVIEWS AND BIBLIOGRAPHICAL NOTES.

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The Work of the Agricultural Economics Research Institute.

Oxford University Press, 1926.

In effect this is a report on the work of the Institute, following that noted in Vol. II of this *Journal*. It covers, briefly, the work of the Institute in farm management, rural life, and miscellaneous studies. Tables or other summarised results of specific studies are shown. Welsh readers would be particularly interested in a summary of some results of a survey of small-holdings in Carmarthenshire which was made by Mr. Edgar Thomas. Of 4,087 small-holders only 2,182 were fully engaged on their holdings and 1,905 had additional occupation. The average rent of 162 holdings was £1 10s. 5d. Money receipts per acre were—highland holdings, £4 8s. 8d.; mixed lowland holdings, £7 9s. 7d.; and lowland milk selling holdings, £11 1s. 3d. After allowing wages for family labour only the milk selling holdings showed a favourable balance between cash receipts and cash expenditures. The full report on this survey will be welcomed, but in the meantime the results as given in this brochure are worthy of study. The brochure is illustrated and the whole of the data is attractively presented. A.W.A.

Reports on Farming Costs of Production and Financial Results.

(1) Milk Production Costs and Financial Results.

(2) The Cost of Food in Milk Production.

James Wyllie, B.Sc. South-Eastern Agricultural College. Price 1s. each.

The first report discusses general costs and results on eleven farms, 1923-24, and twelve farms, 1924-25. Total costs for the first year averaged 15.17d. per gallon, with price 17.22d., and profits 2.05d. per gallon. In the second year total costs were 17.10d. per gallon, average price 16.81d., leaving a net average loss of 0.29d. per gallon. The second report shows cost of grazing at £2 4s. 0d. and £2 5s. 8d. in 1923-24 and 1924-25, with cost per cow at £3 1s. 0d. and £3 6s. 4d. in the respective years. The average cost of food per gallon of milk was 8.68d. and 8.73d. in 1923-24 and 1924-25. Prices of purchased foods and costs of home grown foods are given, and calculations of starch equivalent, etc., per gallon of milk are fully set out. The general economy of the use of foodstuffs in the production of milk is discussed. Two useful reports for those interested in milk production. A.W.A.

Economic and Financial Analysis: East Anglian Farms.

Reports 2, 3 and 4, by J. A. VENN, M.A., and R. McG. CARSLAW, M.A., Farm Economics Branch, School of Agriculture, Cambridge. Price 1s. each.

These reports have all been issued since the abstracts were prepared for Volume II of this *Journal*. Report 2 deals with the accounts of six farms for the year 1924-25 (end of March), Report 3 deals with fifteen farms (Michaelmas), 1924-25. The results of twelve of the undertakings appeared in the report noticed last year and are dealt with for the second year in this report. Report 4 again deals with accounts for seven farms, five of which are dealt with for the second year. Results for these five farms for the first year appear in Report 2. Thus this series is now showing for a number of farms continuous results which are very valuable. Costs for some of the crops are here given.

	Per acre.				
	Wheat.	*Barley.*	*Oats.*	*Potatoes.*	*Roots.*
Michaelmas Farms.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
(14) Harvest, 1924 ...	7 8 0	7 5 0	6 2 0	25 0 0	14 6 0
(15) Harvest, 1925 ...	7 11 0	7 7 6	7 2 9	23 17 6	17 4 0
Ladyday Farms.					
(6) Harvest, 1924 ...	8 1 0	7 12 9	7 14 5	——	12 13 1
(7) Harvest, 1925 ...	7 14 9	8 16 1	8 3 0	33 13 6	10 16 11*

* Mangolds.

The reports show also profits and losses, with various other financial and economic data. Those who are interested in farming costs and financial results should study them in detail. A.W.A.

The Cost of Grazing.

The University of Leeds, No. 144, 1926.

A report which should be of interest to farmers and others in Wales. Conditions in Yorkshire and in Wales are not exactly the same, but are not so dissimilar as to make the conclusions reached wholly inapplicable. The report deals particularly with the cost of grazing cows, but shows the general costs of pasturage. A summary for 1919 shows, for instance, a cost of £3 8s. 8d. per acre, £4 18s. 5d. per "cow equivalent." A summary of grazing costs for varying numbers of farms in each year 1914-1925 shows variations between £1 18s. 0d. and £3 8s. 8d. per acre in 1914 and 1919 respectively. With about sixty farms the average costs per acre were £2 4s. 8d. in 1924 and £2 11s. 10d. in 1925. The full analysis of costs is given. A.W.A.

Cost Account of the Poultry Farm.

C. W. ROBERTS, B.Sc., and R. B. SHAW. *Midland Agricultural and Dairy College, Bulletin* 10, 1926.

A report which should prove useful to poultry keepers and poultry instructors. The operations are described and prices of food are given. Tables showing costs show also quantities of foods. Different methods of estimating the cost of rearing pullets are shown. A.W.A.

CROP ESTIMATING.

(1) An Enquiry into British Methods of Crop Estimating.

J. A. Venn. *The Economic Journal*, September, 1926.

The theme of this article is that the official returns of the English Ministry of Agriculture have always maintained a high standard of efficiency but crop reporters have tended to under-estimate the yield of British farming. Close analysis of past records and an appeal to external evidence suggest that the agricultural position of Great Britain is really better than the official data indicates.

No series of figures representing British crop yield were available prior to 1868. In that year Lawes and Gilbert correlated data relating to wheat yields at Rothamstead with those obtained in other parts of the country. Part I of the official agricultural statistics was issued for the first time in the year 1866 and Part II in 1884. These, the work of crop reporters, provide a continuous review of the state of British agriculture since that year. Wheat improved in the United Kingdom from 29 bushels per acre in the decade 1885 to 1894 to just over 32.6 at the outbreak of War; barley from 33.3 to 34.3 bushels; oats from 39 to 42 bushels per acre. Over England as a whole the shrinkage of area devoted to wheat was beneficial to the yield, but in individual counties where heavy land predominates local yields were reduced. Improvement is indicated by less fluctuation in the average yield from year to year. The maximum departure in the case of wheat from the ten year average since 1886 has been between 3½ and 4½ bushels, only once between 1907 and 1918 has a range of two bushels been exceeded.

The complaint of the writer is that the estimates of the crop reporters tend to be stereotyped and biassed, and he gives examples of errors. The agricultural correspondents of the "Times" differ from the official crop reporters in their estimates of output, invariably giving higher figures. The "Times" estimates are preferred by Mr. Venn because they have not tended to stagnation and have more freely recognised chronological and geographical variations. The official returns deny adequate expression to really good seasons and fail to recognise the influence of the plant breeder. Under-estimates vary by amounts from 5% in the case of wheat through 10% for oats and potatoes to 20% in the case of roots. Mr. Venn suggests the actual weighing of samples and the institution of "standard" plots, in order that their measured yields may be available as basis of comparison, for it is very difficult to assess the weight of grain by the eye or hand.

(2) Report on Agricultural Production in England and Wales.

Agricultural Statistics, 1925, Part II, H.M. Stationery Office, 1926. Price 6d. net.

In England and Wales as a whole, all the main crops except turnips and swedes gave over average yields in 1925, but meadow hay only exceeded the average by a small amount. One of the most noticeable features in the agricultural production during 1925 has been the considerable increase in the production of sugar beet. In the preceding year three factories only were in operation—at Kelham, Cantley and Colwick. Six additional factories were erected in 1925, the total estimated quantity of beet dealt with in 1925-26 being 428,500 tons.

Except for crops on very heavy wet land, wheat came through the wet winter of 1924-25 fairly well. The yield per acre over the whole of England and Wales was rather over 18 cwt. or 1 cwt. above the ten years' average. Spring barley was variable, but yields of oats were above average in most parts of the country. Beans did very well in 1925, but peas varied considerably.

Harvest began early, a start being made on July 10th in the south-east of England; for the whole of England and Wales the average date for commencing the harvesting of wheat was the 6th August. The quality of grain as judged by the natural weight per bushel was of better quality than usual. As a result of the lack of moisture during the summer period there were light crops of straw in 1925.

Potatoes, on the whole, were not planted so early as usual and suffered from the lack of rain in June and the first half of July. The growing weather of August and September had a very beneficial effect on the crop and the final result was a crop of 6½ tons per acre, or 2/5ths of a ton above the average. Turnips and swedes were patchy, mangolds were not very large, but of sound quality. The growth of carrots was affected by the drought, and by the carrot-fly, so that the yield per acre was only moderate.

Although not so heavy as in 1923 or 1924 yields of hay were again above average in 1925.

As compared with the average of the ten years before the War, the production of all the chief crops, except potatoes and sugar beet, was lower in 1925, though the difference in the case of oats was small. Turnips and swedes shewed a loss of 26 per cent., and wheat and barley of 11 per cent. and 15 per cent. respectively, whilst the production of mangolds, beans and peas, was lower by 16, 32 and 41 per cent. respectively. Potatoes shewed an increase of 14 per cent. W.K.

LABOUR AND WAGES.

(1) Report of Proceedings under the Agricultural Wages (Regulation) Act, 1924-25.

H.M. Stationery Office, 1926.

This report records and reviews the proceedings of the Agricultural Wages Board and the District Wages Committees during their first year, and provides various statistical data on wages and hours of labour. The work of the Board and Committees is described, and the rates and conditions fixed for different classes of workers are summarised. Changes in agricultural wages and in the state of employment are discussed. The appendices not only show minimum rates of wages existent at the 30th September, 1925, but changes in rates of wages since 1914. Appendix 8 provides a comparative statement of agricultural wages, prices of agricultural produce, and the cost of living, by index numbers.

(2) Report of the Inter-Departmental Committee on Agricultural Unemployment Insurance.

H.M. Stationery Office, 1926. Price 6s.

In May, 1925, a committee, under the chairmanship of Sir Henry Rew, was appointed by the Minister of Agriculture and the Secretary for Scotland to consider and report whether it is desirable that workers in agriculture should be compulsorily insured against the risk of unemployment, and if so on what terms and conditions. The majority

(six members) reported in favour of the adoption of a compulsory scheme whereby half the contributons should be paid by the State, and half by employers and workers in equal shares, on the assumption that a total contribution of 6d. per week per insurable person would be adequate. The administration of the scheme should be entrusted to the Ministry of Agriculture. The majority were not prepared to recommend a compulsory scheme for Scotland. The minority (five members) stated an opinion that the immunity from the risk of unemployment which workers in agriculture enjoyed in 1920 continues at present in no lessened degree; and recommended that agriculture shall continue to be excepted from the general provisions of the Unemployment Act, 1920.

The evidence throughout this report is of the weakest character, and that relied upon by the majority was ineffectively used. The able destructive criticism of the minority is marred by obvious acidity and venom which was not required for their object of meeting the case presented by the majority. The problem of the incidence of unemployment in agriculture remains unsolved and can be solved only by careful statistical enquiry. The minority report does not adduce any positive evidence of the absence of unemployment. The report as a whole leaves the question of the necessity of unemployment insurance much as it was, except that it has had the effect of postponing any possible action.

A.W.A.

MARKETING OF EGGS AND POULTRY.

(1) Report on Egg Marketing in England and Wales.

H.M. Stationery Office (*Economic Series*, No. 10), pp. 153. Price 6d. net.

This very comprehensive report deals with all problems of egg marketing in this country, and is especially concerned with methods of improving the quality of home produce. In the introductory section the estimate that 80% of the home produced eggs marketed come from smallholders and general farmers shows that improvement of marketing is primarily a farmers' problem. The report then proceeds to point out the dimensions of overseas competition in the post-war egg trade, and to emphasise that this competition is keener than ever owing to the higher standard of quality attained by produce from our near European neighbours.

The burden of the report is concerned with an examination of our marketing system from the standpoint of raising the quality of produce to meet competition. At present there is only a limited application of testing to ensure that all eggs leave the producing localities in a fresh condition, and the equally important question of grading by colour, weight and interior quality has received practically no attention. Moreover, there is ample room for improvement in the methods of presenting produce to the consumer, and the report emphasises the necessity for more standardisation and attractiveness in packing.

The latter part of the report deals with the methods employed by our keenest competitors, which result in sending to our markets a first-class article which often realises a higher price than home produce. Emphasis is also laid on the pioneer work in market reform done by some co-operative societies. Organised action may take the form of State intervention, as it has already done in some countries exporting to us, or of voluntary control, whether by trade associations or of co-operative societies. Great insistence is placed on the necessity of

immediate action on national lines. The conclusion arrived at is that the first step is to set up recognised weight and quality grades which should be the basis of purchase and sale of eggs. This reform, it is urged, would remove the criticism that the present system of buying by count affords no incentive to the production of good-sized eggs.

J.M.J.

(2) A Statistical Analysis of Irish Egg Production, Prices and Trade.

JOHN BUSTEED, M.COMM., F.S.S. Cork University Press.

This bulletin includes studies of both technical and economic data. In the economics of the poultry industry the technical matters are all-important at the present moment. The author, though an economist, has realised this, and his statistical studies of some factors, such as breed, seem to be models of investigational method, even though the final treatment may be too statistical for the average person who is interested in poultry keeping. Some conclusions are clearly stated. There is no relation between quantity and quality of eggs, and increased fecundity does not necessarily mean a poorer type. In any breed the better the type (of bird) the better the output in *every* month, so that a bird which is innately a good winter layer is also innately a good layer at any other time of the year. For seasonal production the conventional division of the year into four seasons does not seem to fit the facts. The biological cycle appears to consist of three sub-cycles of approximately four months each. As regards production and prices, uniformity of monthly production (which characterises high-class pullets) is of importance, both for producer and consumer, because the severe fluctuations in prices are due to the egg-laying fluctuations of a low-type poultry population. The yearly cycle in price fluctuations is noted, and it is suggested that wide variations in monthly price would not occur but for similar wide variations in monthly production, and that they are a proof of the poor type of hen in Ireland. The annual cycle in recent years has shown the most violent fluctuations on record. (These conclusions correspond to those reached in studies of egg production in Wales). The British population consume 120 eggs per head each year, while the Irish consume only 85. If British imports from the Irish Free State in 1924 had been valued on the same basis as Danish eggs they would have been worth £1,000,000 (or 29%) more than their actual export values.

A.W.A.

(3) The Marketing of Poultry in England and Wales.

H.M. Stationery Office (*Economic Series, No.* 11), pp. 122. Price 6d. net.

The thorough analysis of the marketing of poultry given in this report reveals a number of complex problems. Their insistence is not so marked as in the case of the egg trade, since about 75% of our poultry consumption is home produced. But in view of recent improvements in the quality of imports, and of need of improving returns from dead poultry, there is a strong case for reform.

The report shows how the marketing of poultry is a complex business owing mostly to the methods of production, which in parts of this country has undergone a good deal of specialisation of function. This opens the door for wide variations in the technical process, *e.g.*, of conditioning, besides the danger of a good deal of misunderstanding between various

classes of producers. Again there are wide variations in the seasonal demand for each type of poultry, together with specialised demands for birds falling within certain age and weight limits. In view of these factors the report emphasises that producers and distributors should be in possession of a large amount of highly technical knowledge, and that they should, for the benefit of the industry as a whole, co-operate in the dissemination of this information.

The immediate action should take the form of improvement and standardisation in methods of preparing poultry for market both prior and subsequent to killing. At present there is entire lack of uniformity in the weights of birds, together with a good deal of ignorance in the dressing of poultry. This is reflected in the preference which many distributors show for the more uniform supplies from abroad, since " imported poultry can be sold on a sample box; practically every parcel of English fowls, on the other hand, must be unpacked in the market, examined and sorted into level lots before sale." While conditions such as these prevail the marketing of poultry cannot be termed efficient, and the report suggests the adoption of quality grades, and recommends that more practical instruction should be given in the preparation of produce for market. J.M.J.

MARKETING OF LIVESTOCK AND MEAT.

(1) Imperial Economic Committee.

Report of the Imperial Economic Committee on Marketing and Preparing for Market of Foodstuffs Produced in the Overseas Parts of the Empire. First Report General. Cmd. 2493, 1925. Price 9d.

(2) Second Report.

Meat. Cmd. 2499, 1925. 9d.

In view of the recent sittings of the Imperial Conference and the grave position of British industry these two reports will be read with interest. Even to the producer of foodstuffs at home there is a good deal of matter which he will find helpful as showing sound marketing requirements.

The first report, after a survey of the position of the home producer, discusses the means for the identification of Empire produce and makes definite suggestions for bringing this about; it recommends that financial assistance be given for publicity and research; this money to be allocated by an Executive Commission on the lines of the Development Commission. The need for research to perfect old and institute new methods is emphasised. There are statistical appendices and tables. The recent Merchandise Marks Bill seeks to carry out some of the suggestions of this report. The sum of a million a year is recommended in the report as necessary, of which 65% would be for publicity and education and the promotion of trade in Empire produce, 15% for research, and 20%, the remainder, for other schemes and projects to help Empire trade in foodstuffs.

The second report (above, Cmd. 2499) deals with the meat supply of the United Kingdom, the sources and nature of the import and the part contributed by the Empire. It then details the beef trade of the United Kingdom market and gives an excellent objective view of the position in this market of home-grown, chilled and frozen supplies. The

necessity of improvement in Empire stock and a revision of cold storage charges are indicated. Similarly we have sections on mutton and lamb, pig products and canned meat and fish. The conclusions and suggestions as to the urgent need of meeting foreign competition are based not on the lines of preference or tariffs, but on insisting on marking foodstuffs with place of origin both by importer and retailer. Quicker transport from Australia and New Zealand, better pedigree stock and improvement in grading and standardisation of beef are urged as essential steps in the building up of a greater Empire beef trade.

(3) Report on the Trade in Refrigerated Beef, Mutton and Lamb.
H.M. Stationery Office (*Economic Series, No.* 6), 1925. Price 1/6.

While the two previous reports cited deal with the business side of the question of marketing and preparing for marketing Empire meat, this report, while in the main a descriptive account of the whole world trade, contains a scientific economic analysis of the underlying factors which account for the present predominance of our foreign imports of beef and our Empire strength in mutton and lamb. Like all this series it has an excellent statistical chapter with charts and graphs showing the sources, values and volume of supplies from different parts of the world. It examines the relative predominance of South America, especially the Argentine, in our home market for beef, explains why New Zealand secured her demand here; then follows an excellent account of the trade in Great Britain, giving types of sale, surveys for insurance and quality, wholesale merchanting and retail distribution. There is also an examination of combinations in the industry, and an account of the New Zealand Meat Producers' Board and the Australian Meat Council.

Its concluding observations are by no means as optimistic as those of the two previous Imperial Committee reports. It is more scientific and less hazy. The main factor in the future is the growing continental demand for frozen beef—a new phenomenon which is bound to affect our prices for higher qualities—even chilled beef may be required there in the near future; if so, our prices of imported beef are likely to rise and "by narrowing the margin between refrigerated and fresh-killed supplies, may afford a new and incalculable stimulus to home production." The close connection between the world demand for wool and the available mutton supplies is indicated, and when wool supplies are adjusted to demand mutton it is probable that supplies will increase. The world beef market is likely to remain firm, but there are changes—in areas of supply, in meat exporting capacity, in the technique of refrigeration and transportation, in trades and demands in areas of consumption—which make any sound generalisation as to the future very difficult to make. For instance, a technical invention which may bring Australian chilled meat to our market would affect profoundly the nature and direction of our meat trade. Conditions are uncertain and bound to be different in a year or so. This report ought to be read by every farmer who sells beef, mutton or lamb. J.M.R.

Report on the Marketing of Pigs in England and Wales.

H.M. Stationery Office (*Economic Series, No.* 12), 1926. Price 6d. net.

This report is based on an enquiry into the marketing of pigs in England and Wales, but is not entirely concerned with marketing.

Reference to the conditions of production is always required in the study of markets and their conditions. This is particularly the case as regards pigs, since home production is out of harmony with demand. The demand for pork and bacon has increased with the number of the population, but production remains about the same as it was about fifty years ago. The demand for pork is relatively inelastic, and when the temporary effect of the pork embargo has passed producers must look to the bacon industry if production is to be increased. Pig producers have not been able to respond to the demands of the bacon market in the past, but there is nothing in the environment of the industry that can be held to obstruct progress. Essential steps are to provide curers with assured and sufficient supplies of the right kind of pig, and the development of the curing industry. For these, working arrangements of mutual benefit to producers and curers are required. It is impossible to summarise the mass of data in this volume, for much of it is in the nature of discussion. Here and there the strength of statement tends to exceed that of evidence or authority. More references to authorities would have added to the value of the work, for it is obvious that in some cases authority is secondary, and may be tertiary. Evidence is sometimes weak, especially on what is called " the gamble of the store market ", and on the relative advantages of the pork and bacon markets. While the conclusions may be correct the evidence presented is not alone sufficient for proof. A section on the cyclical character of production is scarcely adequate, and we shall not know much of pig production until we can learn more of the causes of cyclical fluctuations. If the pig supply of U.S.A. is dependent on the maize crop of the preceding year (p. 24) Diagram B indicates that the time-lag in this country is frequently two years. The diagrams are generally good, but for Diagram D the time-period base should have been the same for all the items. The actual relationship between three items is not necessarily indicated when two indices are on one time-period base and the third index is on another.

A.W.A.

Co-operative Bacon Factory Industry.

Report of a Committee of Investigation appointed by the National Farmers' Union. N.F.U.- Price 6d.

This Committee enquired into the economic position of the co-operative bacon factories with a view to making recommendations for its improvement. The report describes the history and equipment of six factories, and discusses their problems in matters of capitalisation, equipment and technique, and administration. The difficult problem of the relation between farms and factory in the supply of pigs is also discussed. Methods of selling are described. In view of the fact that English bacon-curing establishments, both co-operative and non-co-operative, are not, on the average, utilised to more than half their full capacity, the Committee do not recommend any general extension of curing facilities for the time being. Possibilities of extension in special localities, presumably, are not excluded. The Committee did not agree on the vexed question of contracts for pigs. Two members felt that the producers' point of view against the binding contract system is overwhelming, while four are of the opinion that there is no completely satisfactory alternative to the membership-contract. This is a very informative and useful report and it should be of practical assistance to all those who are interested

in the development of co-operative bacon factories. It could have been improved by the inclusion of some of the financial and statistical data which the Committee must have collected, and this could have been done in some cases without publicly divulging the private business of any one of the individual factories. A.W.A.

The Marketing of Live Stock.

F. J. PREWETT. Clarendon Press, 1926.

This is a study of systems of marketing live stock in the neighbourhood of Oxford. Some of the conditions described are local, while others are to be found over much wider areas. As the work is largely descriptive summary is difficult. The description and discussion covers *inter alia* the arrangement of markets and their transport facilities; the functions of auctioneers, dealers and butchers in businesses of different types; production and movements of live stock; and channels of meat distribution. A discussion of the deficiencies of existing distributive agencies leads to suggestions for reorganisation of trade in fat stock and meat. Cost is the most serious disadvantage, from the farmers' point of view, of the present means of live stock marketing. Next in importance is uncertainty of prices. The farmer has neither knowledge of, nor control over, supply, beyond that which he individually decides to dispose of. Stabilisation of price cannot be attained until farmers organise to control the incidence of supplies and so to secure for themselves the price ruling generally over the country. The most effective way of securing this control, and at the same time of reducing marketing and slaughtering costs to a minimum, is to build co-operative slaughteries as an adjunct to the farmers' markets. The ultimate object of marketing reform is that the organised producer shall sell direct to the organised consumer. Possibilities and methods of co-operative organisation are discussed. The illustrations are excellent, but some of them indicate practical possibilities of improvement far short of and not necessarily leading towards the ultimate requirements as visualised by the author. One of the most important contributions of this book to its subject is the description of the market " ring " and " knock out," which is the best yet seen. Generally, idealism is combined with detailed practical knowledge and realisation of the difficulties of reform. The facts and ideas are presented in a very attractive form. A.W.A.

MARKETING OF POTATOES.

(1) Report on the Marketing of Potatoes in England and Wales.

H.M. Stationery Office (*Economic Series, No.* 9), 1926. Price 1/6 net.

The introduction states that " This report is the result of a detailed enquiry into the method by which potatoes pass from producer to consumer." The potato crop " is the most important raised on British farms and exceeds any cereal crop in value of output." Much of the material collected in this report has never been available before to those interested in the problem. The report, which is well illustrated, opens with a discussion of maincrop and early potatoes and their prices. From about Easter the trade looks southward for supplies of earlies. Many of the sources lie outside this country, *e.g.*, the Canary Islands, Jersey and Guernsey, Spain and Brittany. Home grown earlies are produced in Cornwall and Scilly Islands, in Bedfordshire, in South Lincolnshire and

Cambridgeshire, and in Lancashire and in Cheshire. In dealing with earlies the trade pays little regard to particular varieties. There are only two kinds recognised in the home trade, " rounds " and " kidneys." About September the trade begins to quote for different varieties. In some markets the soil classification is all-important. A consignment from a light soil will, in any market, command £1 per ton more than one from a dark soil. Apart from their kindliness and freedom from disease, which are taken for granted, the fact of most importance is size. Grading is a question that calls for attention, and an account is given of the systems in vogue in Canada, Germany and United States.

Before the war farmers despatched a large proportion of their potatoes loose in waggons. They are now chiefly sent to market in sacks. A suggestion is made that a standard minimum size might be laid down for sacks; the size most commonly used is 22in. by 46in., returnable or non-returnable. Barrels, hampers and boxes are also mentioned.

Many of the elements which go towards the constitution of a satisfactory price-making market are present; there is the gathering of a representative number of growers, grower-merchants and dealers, and a wide inter-change of views upon the prospects of the trade. In order to stabilise the market a system of day to day business intelligence is desirable.

Wholesale and retail marketing and carriage are dealt with in some detail. Large producing areas lie at some considerable distance from the consuming centres. The railway remains the chief means of transporting potatoes, but the use of motor transport has greatly increased for haulage up to twenty, twenty-five or even sixty miles. Beyond 120 miles, transport by sea, where conditions are suitable, is most favoured. The present position of producers' co-operative efforts in the marketing of potatoes is described and large scale organisation suggested.

The problem of dealing with temporary surplus supplies is a difficult and urgent one. The British surplus is due generally not to imports, but to a very heavy home crop. Products like alcohol, starch, flour, dextrin and glucose may be manufactured from potatoes; these products, however, have no industrial significance in this country. In any case the production of potato spirit is unremunerative and was only made possible in Germany, before the war, by state subsidy. As an alternative the method of surplus insurance is explained. The report closes with chapters on the co-operative organisation of buyers and the seed trade.

(2) Economic Aspects of Local Potato Warehouse Organisation.

JOHN D. BLACK and others. University of Minnesota, 1925.

This pamphlet and the two following should be read in conjunction with the above as giving a detailed and businesslike survey of the principles and practice of potato marketing in the U.S.A. This particular paper gives detailed treatment of costs and finance.

(3) Factors determining the Prices of Potatoes in St. Paul and Minneapolis.

HOLBROOK WORKING. Univ. of Minnesota, 1922.

A technical study of considerable value to those who wish to learn the economics of price control as applied to potatoes.

(4) Local Co-operative Potato Marketing in Minnesota.

JOHN D. BLACK and others. Univ. of Minnesota, 1921.

There are sections dealing with the organisation of co-operative societies for potato marketing, with their finance and equipment, and with methods of buying for dealers. Pooling, both of stocks and of price, already applied to wheat and other commodities, is suggested as a method of marketing potatoes. The pooling period suggested is one month, prices to be shared according to the quality of the potato supplied. Further chapters deal with the pooiing of expenses, problems of markets, terms of sale, sorting and grading, accounting and choosing of manager. W.K.

MARKETING OF WOOL.

Report on Wool Marketing in England and Wales.

H.M. Stationery Office (*Economic Series, No. 7*), 1926. Price 1/6 net.

The results of the investigation into wool marketing conducted by the Ministry in 1925 are embodied in this report. Home grown wool is usually only a side-line in the production of mutton and lamb. Farmers, however, should try to harmonise the two products; and in any case the study of methods of efficient marketing of wool is of great importance.

The report deals with the production and distribution of sheep and the supply and demand for wool. A general decline in the keeping of sheep is evident. For the time being wool supplies are adequate, but a restoration of pre-war industrial activity is likely to produce a shortage of this raw material. An increasing amount of British wool is being exported. In the report long period prices are traced from 1812 to 1924 and the importance of Australian and South African competition shown. Seasonal prices show appreciable fluctuation.

Dipping and marking influence the quality of the clip. It is difficult to lay down a general rule with regard to washing for buyers differ in their demands. Considerable improvement in the preparation of wool for the market is necessary, for badly prepared wool cannot command the price of the well prepared.

There is a variety of methods in selling. The grower may sell by private treaty, at country auction sales, at auction sales in London or Bradford, or on the co-operative method which has developed extensively in the last few years. Only a small number of British clips are graded before sale, but grading is an advantage, for buyers come not only to buy wool but a particular kind of wool. There is an interesting section on the conduct of sales and on central markets.

Many pages of the report are devoted to co-operative selling. Co-operation amongst producers enables them to make and take opportunities for selling to alternative markets. It helps to stabilise auction sale by offering wool in comparatively large and well prepared lots. Methods of organisation differ. A group of farmers may agree to sell through one broker or through their society. Again, an officer of the society may go round the farms with a buyer and introduce sellers. Or again, a large association may set up a separate wool department. There is an account of the Kent Wool Growers' Society and the Southern Wool Growers' Depot at Chichester. Obstacles to co-operative development are the scattered nature of sheep farming, the existence side by side of growers of unequal productive efficiency and marketing strength, and the problems of management. W.K.

PRICES AND CREDIT.

(1) Report on Agricultural Credit.

H.M. Stationery Office (*Economic Series, No. 8*). Price 1/6.

So much has been written on agricultural credit and so little accomplished as a result that one becomes rather sceptical of the need for additions to the existing publications however good they may be. Mr. Enfield, however, in this report, has presented his study of the agricultural credit problem in this country with such skill and conclusiveness that one cannot fail to realise and appreciate the difficulties that confront the farmer of to-day, and these become more acute as the process of changing ownership goes on.

The report deals with the historical aspect of need of credit in industry, the rise of joint stock banking to meet that need, and the lack of such facilities in agriculture. It points out that as a result of our land tenure system the chief credit problem in this country is one of short term loans as affecting the marketing of agricultural produce. In another chapter the existing facilities for obtaining credit are dealt with, and we are led to the conclusion that these fall far short of the ideal that credit should be based on agricultural wealth. The chapter on short term credit facilities in the U.S.A. is of interest and value as pointing a way in which Great Britain could follow, with the necessary adaptation, the lead of that country. Chapter 5 suggests that legislation should be enacted enabling a valid charge on certain assets to be given in favour of the banks in the form of a chattel mortgage, making the stock and crops sufficient security for loans of money to farmers. As regards long term credit the proposals follow to a certain extent the methods obtaining in the U.S.A., but they differ by proposing to create only one new institution, namely, the Central Land Bank, which would advance long term loans through the Joint Stock Banks.

The Joint Stock Banks are a growth of the industrial revolution, and as such can meet the credit requirements of the large corporate concerns which made it possible for them to exist. One cannot say as much as far as the satisfaction of the credit needs of the farmer are in the question. The co-operative credit systems practised abroad, though sound in principle and in practice in their environment, have not met with any measure of success in this country, and therefore cannot be considered at present. Mr. Enfield indicates another way by which many of the difficulties, real and assumed, in connection with agricultural credit can be effectively overcome. A.J.

(2) Some Causes and Effects of Changes in Prices of Farm Produce.

A. W. Ashby, M.A. *Author's Reprint from the Journal of the Royal Agricultural Society of England*, Vol. 86, 1925.

This article is exactly the analysis required by the farmer and student who seeks to know the reason why price changes of agricultural produce are often more profound and disastrous than changes in the general level of prices. A note of warning is also given that where demand is inelastic (and this is the case for some kinds of farm produce) the remedy of finding alternative markets for seasonal variations may not be possible. Prices again may not regulate production in agriculture in the case of eggs, butter and milk, because variations in supplies are

normal from year to year. The author discusses three suggestions of scientific remedy, *e.g.*, increasing production in periods of relative shortage and decreasing them in present surplusage, changes in marketing methods brought about by new storage possibilities, and alternative use of product during periods of heavy supplies. Finally, there is a useful discussion of the possibility of securing a fairly stable level of prices by the control of the issue of currency and credit. Even if this be achieved, and the general price level stabilised, it does not follow that the prices of products in the composite group of industries described as " agriculture " would be stable, unless attention is concentrated on the method of production and consumption of the individual product.

This is a highly interesting and valuable scientific study of the underlying economic forces both on the production and marketing side of agricultural products. J.M.R.

ANIMAL NUTRITION.

Abstractor: R. O. Davies, M.Sc., University College, Aberystwyth.

Calorimeter; A new—for use with young Farm Animals.

Thomas Deighton. *J. Agric. Sci.*, 1926, 16, 376-382.

Description of a new calorimeter in use at Cambridge for accurate measurements with young animals. R.O.D.

Clamp Silage; A Study of the Process of making.

A. Amos and H. E. Woodman. *J. Agric. Sci.*, 1925, 15, 444-453.

The making of clamp silage from a loosely-packing crop like oats and tares under ordinary field conditions may lead to excessive losses both from fermentation, if " sour " silage results, and from wastage on the outside if the silage is kept long into winter or is inadequately covered. The practice should not be undertaken lightly when haying conditions are good. The most satisfactory results are only to be obtained where painstaking precautions are taken in regard to filling and finishing off. R.O.D.

Dairy Cows; Calcium and Phosphorus Metabolism in.

E. B. Meigs, W. A. Turner, T. S. Harding, A. M. Hartman and F. M. Grant. *J. Agr. Research*, 1926, 32, 833-860.

The changes in the calcium and phosphorus content of the bodies of milking cows do not run exactly parallel, but a long continued loss of calcium from the body will cause a roughly corresponding loss of phosphorus even though the ration may contain plenty of assimilable phosphorus. The rate at which calcium is assimilated from hay depends on its treatment after being cut, the rate being very low for hay that has been rained on. The average proportion of calcium assimilated by milking cows from well cured hay amounts to about 20% of the intake. The addition of cod liver oil to the ration had no favourable effect on calcium assimilation. The results indicate that phosphorus assimilation may be interfered with by any excess of calcium in the ration and that two parts or more of calcium to one of phosphorus constitutes an excess. R.O.D.

Dairy Cows; Mineral Nutrients in the Rations of.

J. B. ORR, A. CRICHTON, J. A. CRICHTON and W. MIDDLETON. *Scottish J. Agr.*, 1925, 8, 312-318.

The effect of a mineral mixture composed of $CaCO_3$ 56, NaCl 28, Fe_2O_3 1 and KI 0·125 parts and fed at the rate of 85lb. per ton of compound cake used in the ration was determined on six dairy cows, six cows also being carried as controls. The average milk yield and the average weight of the calves tended to increase in the second lactation with the cows receiving the mineral mixture, while with the control animals there was a decrease. The health of the animals receiving the mineral mixture was better than those receiving no minerals, with the exception of delay in cleansing after calving. The work is being continued.

R.O.D.

Lactose Residues; Pig-feeding Experiments with.

J. GOLDING and W. B. MORRIS. *J. Ministry Agr.*, 1926, 32, 911-918.

After the removal of the easily crystallised lactose from concentrated whey the residue (lactose paste) was fed to pigs directly or after mixing with brewers' grain (lactose feed). Meat production was slightly more economical in pigs fed with lactose feed than in controls in which equal amounts of bean meal were substituted for the lactose feed. Inclusion of 10% lactose paste also gave satisfactory results. Superior quality of flesh was obtained with lactose products in the diet.

R.O.D.

Lactose Feed as a Food for Dairy Cows; a Preliminary Experiment.

K. W. D. CAMPBELL. *J. Ministry Agr.*, 1926, 32, 918-919.

Lactose feed (cp. preceding abstr.) has a value similar to that of bean meal in the diet of milch cows. R.O.D.

Nutrition; Influence of Ultra-Violet Light on.

J. M. HENDERSON. *Scottish Journ. of Agric.*, 1926, 9, 33-39.

Irradiation by means of the carbon arc lamp caused an increased retention of calcium and phosphorus by the pig. Irradiation exerts its maximum effect when, as a result of a badly balanced diet or from other cause, the retention of minerals is low. When the retention is already good irradiation may have but little influence. In three experiments with lactating goats the effect of the light treatment has been slightly but definitely to raise the amount of calcium retained by the animal.

R.O.D.

Nutrition; Studies of the Nutrition of Young Animals.

1. Energy exchanges in the growing pig. T. B. WOOD. *J. Agric. Sci.*, 1926, 16, 425-442.

Facts and considerations for computing a series of rations which from the energy point of view will produce any desired rate of live-weight increase within the capacity of pigs of the Large White breed.

R.O.D.

Pasture Grass; Mineral Content of—and its effect on Herbivora.

W. Elliot, J. B. Orr and T. B. Wood. 1. General. W. Elliot. 2. Effect of addition of mineral salts to the ration of sheep. W. Elliot and A. Crichton. 3. Analyses of samples of British pastures. W. Godden. 4. Seasonal variations in mineral content of pastures. (Miss) E. M. Cruickshank. 5. Effect of fertilisers on mineral content of pastures. W. Godden. *J. Agric. Sci.*, 1926, 16, 59-64, 65-77, 78-88, 89-97, 98-104.

1. There is no striking difference in energy value between good and poor pastures. Wide differences occur in mineral composition, a high mineral content being associated with a high nutritive value.

2. " Bent leg " in sheep appears to be due to a mineral deficiency, and to be correlated with a general lower nutrition. Pastures with mineral deficiencies are correlated with high stock death rates.

3. The herbage of the hill pastures in Great Britain is, in general, markedly poorer than that of the cultivated pastures in silica-free ash and in individual constituents with the exception of sodium. It is also poorer, but to a less extent, in nitrogen. Ungrazed herbage from the hill pastures is poorer in ash than the grazed herbage. Wherever sheep have a free choice in grazing they appear to eat, by preference, that herbage which contains the higher percentage of mineral ingredients.

4. There is a definite seasonal variation in the mineral content of pasture grasses. This is more marked in good than in inferior types. The variation is most pronounced in the case of the calcium oxide. It is suggested that the period at which the content of ash and of the individual constituents reach a maximum is influenced by the nature of the grazing.

5. Application of artificial fertilisers to grassland may result in considerable modifications in the mineral content of the herbage of these pastures. The constituents which appear to show the biggest variations are calcium and potassium, and, to a lesser extent, phosphorus. Coupled with any marked increase in the calcium content of the herbage there is generally to be found an increase in the percentage of nitrogen.

R.O.D.

Pastures; Mineral Content of.

J. B. Orr, W. E. Elliot and T. B. Wood. *Scottish J. Agr.*, 1925, 8, 349-59.

See previous abstract from " Mineral content of Pasture Grass and its effect on Herbivora " by the same authors.

With the exception of sodium there appears to be a definite correlation between the various mineral constituents of pastures, samples having a low content in one element tending in general to have a low content of the others. In certain samples it appeared that lack of calcium had limited the power of the plants to utilise chlorine. In the analysis of samples from the Falkland Islands it was found that grass near the sea contained appreciably greater amounts of nitrogen and all of the essential mineral elements than grass from inland.

From experiments on the feeding of lambs it appeared that both linseed and olive oils had a depressing effect on growth, but cod-liver oil and Ca salts had a marked beneficial effect when added to rations deficient in calcium. R.O.D.

Pasture; Nutritive value of.

1. Seasonal variations in the productivity, botanical and chemical composition, and nutritive value of medium pasturage on light sandy soil. H. E. Woodman, D. L. Blunt and J. Stewart. *J. Agric. Sci.*, 1926, 16, 205-274.

As a result of frequent and close cutting wild white clover flourished and spread. The total yield per acre from hay plots (hay plus aftermath cuts) was more than twice as great as that obtained by a system of frequent cuts from the pasture, but in comparison with the hay there was a very high percentage of protein and a low percentage of fibre in the pasture cuts.

The digestion trials showed that pasture grass possesses a much higher nutritive value than has hitherto been thought, and its dry matter can be compared with concentrates like linseed cake. The high degree of digestibility of the fibre is specially notable. The digestibility of the grass varied during the season but at its lowest was superior to that of the best meadow hay. The hay and aftermath cuts resulted in the production of only two-thirds of the amount of digestible protein obtained from the pasture plot.

The mineral constituents of the pasture showed definite seasonal variations. It is emphasised that the magnitude and kind of variation may be markedly different in different pastures. The range of variation for the phosphate was not so wide as with the lime. R.O.D.

Poultry; Digestibility Trials with.

1. The Digestibility of English Wheats, with a note on the Digestibility of Fibre in Sussex Ground Oats. E. T. Halnan. *J. Agric. Sci.*, 1926, 16, 451-458.

Except in the case of crude fibre and ether extract poultry appear to be able to digest wheat as efficiently as other farm animals. Poultry are, however, distinctly inferior to other farm animals in their capacity to digest crude fibre and ether extract. The experiment with oats further illustrates the fact that poultry digest crude fibre with difficulty. R.O.D.

Poultry; The Nutritive Requirements of.

J. B. Orr, M. Moir, A. Kinross and G. S. Robertson. *Scottish J. Agr.*, 1925, 8, 263-269.

Experiments were carried out to determine whether ordinary well-balanced rations fed to poultry kept under practical conditions were improved by the addition of substances reputed to be rich in vitamins. Addition of cod-liver oil as a source of vitamin A did not increase the rate of growth or egg production. Negative results were also obtained with vitamin B in the form of yeast, and vitamin C in the form of fruit and vegetable juices. In order to determine the effect of mineral salts on egg production a mixture composed of $Ca_3(PO_4)_2$ in the form of bone flour 100, $CaCO_3$ as chalk 40, NaCl 40, S 10, Fe_2O_3 10, and KI 1 part was fed in varying amounts in addition to a well-balanced mash. In three experiments lasting from five to twelve months there was a total increase in egg production, over the controls, of 25% to 70%. The value of the inorganic constituents of fish meal was shown in two experiments in which this material was substituted for bean meal and blood meal respectively. R.O.D.

Silage Experiments at Albert Agricultural College.

J. P. DREW. *Journ. Dept. of Lands and Agric., Irish Free State,* 1926, 25, 290-296.

Silage made from a mixture of beans, vetches and oats may partly replace concentrated foods for the feeding of dairy cows and the winter fattening of cattle. There seems, however, to be a limit to the amount of silage that may profitably be fed to either a fattening bullock or a dairy cow. R.O.D.

Stack Silage; Study of the Process of making.

H. E. WOODMAN and F. HANLEY. *J. Agric. Sci.,* 1926, 16, 24-50.

An account of experiments on stack ensilage. The loss of dry matter in the " sweet " silage layers of the stack compared favourably with those obtained in tower ensilage, and was appreciably smaller than that associated with the production of " sour " silage in the clamp.

The effect of initial high temperatures in largely inhibiting the cleavage of protein into amino acids during ensilage is attributed to the destructive influence on the plant enzymes of the high temperatures attained in the stack during the first forty-eight hours.

In stack ensilage the amount of ether soluble material decreases during storage. The depression in protein digestibility is shown to be due in large measure to the bacterial transformation of part of the protein to a dark brown humin-like material. R.O.D.

Sugar Beet Tops; The ensilage of.

H. E. WOODMAN and A. AMOS. *J. Agric. Sci.,* 1926, 16, 406-415.

The preservation of sugar beet tops must be looked upon as an emergency measure to be adopted during times of food scarcity. It is shown that if whole tops be ensiled and care taken to ensure tight packing, silage of good quality results. The preservation may, however, be accompanied by big losses of food material as a result of copious drainage away of juice. The possibility of reducing such drainage losses to a minimum by ensiling a mixture of tops and wheat chaff or other absorbent material is indicated.

On farms situated in the vicinity of sugar beet factories the production of silage from sugar beet tops and wet sugar beet pulp ensiled in alternate layers offers attractive possibilities. Again, however, there may be heavy losses of nutrients owing to the wetness of the ensiled material. R.O.D.

Wheat and Corn (Maize) Kernel; Nutritive value of various layers of the.

A. KLEIN, B. HARROW, L. PINE and C. FUNK. *Amer. J. Physiol.,* 1926, 76, 237-246.

Feeding tests and chemical fractionation of the proteins of various milling fractions of wheat and maize combine to show that those fractions which contain the peripheral layers possess proteins of higher biological value than those which contain the endosperm. The outer layers are richer in globulins and glutelins and poorer in gliadin (or zein). It is difficult to define the respective parts played by vitamins and proteins in the enhanced nutritive value of the peripheral layers, since there is some evidence that these two factors are inter-related.

R.O.D.

ENTOMOLOGY.

Abstractor: J. R. W. JENKINS, M.Sc., University College, Aberystwyth.

Big Bud Mite; The Control of—in the Field.

HATTON, AMOS and TYDEMAN. *Annual Report, East Malling Research Station*, 1924.

The authors describe experiments, the results of which show that spraying with lime sulphur again was the most efficient method of reducing the rate of spread of the big bud mite. The best time to spray is when the flower racemes have appeared, but before the flowers have opened. Slight scorching of the young leaves generally occurs, but no permanent damage appears to result. Spraying with lime sulphur and hand picking of big buds reduced the spread of reversion from 23% on the untreated plots to 4% and 5% respectively on the treated plots.
J.R.W.J.

Cyaniding; A new Method of.

E. C. *Gardeners' Chronicle*, LXXVIII, No. 2,014, 1st August, 1925.

Instructions are given on the fumigation of greenhouses with calcium cyanide, which is cheap, safe and reliable. It kills aphides and the adults and larvae of the tomato whitefly. J.R.W.J.

Diamond Black Moth; The.

THEOBALD. *Journal of the Kent Farmers' Union Reprint*, Sept., 1926.

The economic importance of this pest of cruciferous plants is discussed in detail. Descriptions are given of the various stages in its life history, and of its life cycle, habits and distribution. The control of the pest is fully considered under the headings—effects of weather, natural enemies, and artificial measures, the latter being subdivided into mechanical control and spraying and dusting. J.R.W.J.

Frit Fly; Studies on. The Correlation between Stage of Growth of Stem and Susceptibility to Infestation.

CUNLIFFE, FRYER and GIBSON. *Annals of Applied Biology*, XII, No. 4, November, 1925.

Oat plants of known history were exposed to the attack of *Oscinella frit* in different stages, being screened from attack before and after exposure. These plants were compared with unscreened plants of the same stage to gauge infestation. Control plants, screened throughout their growth, showed no infestation, thus proving the efficiency of the screening. The susceptibility of the main stem to attack was found to be most marked during the two-leaf and three-leaf stages of growth. In the four-leaf stage susceptibility decreased, and beyond this stage the shoot seemed to be relatively immune. It therefore appears that damage by *O. frit* can be avoided by early sowing (as is well known), or by a selection of a variety of oat which passes quickly through all stages of growth prior to the four-leaf stage. J.R.W.J.

Grub Pest, and Paris Green as a Remedy; The.

West of Scotland Agricultural College Bulletin, 103, 1925.

Serious damage to various crops, oats and turnips in particular, by various species of leatherjackets, is discussed. Larval habits, and the

lethal effects of various climatic conditions, are dealt with, and recommendations given as to the most satisfactory methods of artificial control.

J.R.W.J.

Hippobosca equina; On the Bionomics of.

ROBERTS. *Annals of Tropical Medicine and Parasitology*, XIX, 1, March, 1925.

" Forest flies "—blood-sucking pests of cattle and horses, and occasionally dogs, are shewn to have a limited distribution in North Wales. The mode of dispersal of the pest is discussed, and it is shewn that two factors influencing its distribution are the presence of bracken, on which depends successful pupation, and the amount of sunshine available. Its economic importance is considered and the various features of its life history described. J.R.W.J.

Insect Pests and Fungoid Disease; General Principles relating to the Control of.

PARKER. *Horticultural Trade Journal Reprint*, 1926.

Among the general methods of insect control dealt with, the author discusses dormant and summer sprays, fumigation, dusting, the control of greenhouse pests, and partial soil sterilisation by means of heat and chemicals. J.R.W.J.

Potato; Investigations on the Leaf-roll and Mosaic Diseases of the.

MURPHY and MCKAY. *Department of Lands and Agriculture Journal, Ireland*, XXV, No. 2, August, 1925.

Experimental infections of plants with leaf-roll and with mosaic diseases have been successfully carried out through the agency of the aphides *Myzus persicae*, *Myzus psuedosolani* and *Macrosiphum solanifolii*, whilst proof has been obtained that leaf-roll is occasionally conveyed by the true seed. This apparently holds good for diseases of the mosaic group. J.R.W.J.

Potatoes in North Wales; Insects attacking.

WALTON. *Annals of Applied Biology*, XII, No. 4, Nov., 1925.

A record of observations made during the years 1921-1924 principally in Anglesey and Caernarvon, the data being obtained chiefly in view of the importance of insects as transmitters of the virus diseases.

Poultry; The use of—against Farm Pests.

ROEBUCK. *Eggs*, XI, Nos. 12, 13, 25. XII, Nos. 1 and 3. March-July, 1926.

The value of fowls as destroyers of insect pests on arable and grass land and on mustard and willows is pointed out. Although wireworms were always eaten first by fowls if given to them amongst other larvae, they are usually not found in the field, as they are too deep in the soil. Poultry are, therefore, of use in keeping down these pests only when ploughing or some other form of cultivation is in progress. For the destruction of the adult beetles fowls should be run from early May to July on grassland and clover adjoining arable land. Leatherjackets are best combated by running fowls on arable land during cultural operations, and during the winter months, when the larvae crawl upon the

surface of the ground. Fowls may be also used with success to control such pests as cutworms, mustard beetles and willow beetles.

J.R.W.J.

Red Spider; The Control of.

PARKER. *Horticultural Trade Journal*, XXIX, Nos. 39 and 40, 30th September and 7th October, 1925.

Particulars are given of the method of controlling red spider (*Tetranychus telarius*) in greenhouses by volatilising naphthalene with paraffin lamps. Type of naphthalene, dosage, and the precautions necessary are stated, and the conditions best suited for the various types of greenhouse crops are tabulated as a guide to their fumigation. The method results in a kill of 90%—95%. J.R.W.J.

Slug Pest; The.

ANDERSON and TAYLOR. Publication No. 143. *University of Leeds Agricultural Department.* March, 1926.

The results of the experiments may be summarised as follows:—

The spraying or dusting of irritant substances, to be effective, must be done at night when the slugs are on the surface, so that the substance comes into contact with the *upper* part of the slug's body.

The most effective substance is copper sulphate, and the most effective method of application is to mix 6lb. of finely ground copper sulphate with 1cwt. of commercial kainit, and distribute the mixture by hand or by a manure distributor at the rate of 3cwt. per acre. Applications of lime and salt do not prove effective unless they are repeated two or three times at short intervals during the same night.

J.R.W.J.

Strawberries; Progress Report on Red Plant of.

LEES and STANILAND. *Annual Report, Agricultural and Horticultural Research Station, Long Ashton, Bristol*, 1924.

Regarding the supposition that "red plant" and "cauliflower disease" in strawberries are both caused by reaction to infestation by the eelworm *Aphelenchus fragariae* R.B., it is pointed out that the eelworm may be found in comparatively large numbers in normal plants. The authors consider that for an explanation of the different manifestations of the disease other factors must be investigated. Whilst accepting the presence of nematodes as a necessary hypothesis for the moment, they suggest that their presence alone is not sufficient. J.R.W.J.

Tomato Houses; The Fumigation of—with Hydrocyanic Acid Gas.

SPEYER and OWEN. *Annals of Applied Biology*, XIII, No. 1, February, 1926.

The authors describe method of cyaniding greenhouses by means of a mixture of one part by weight of fairly finely divided sodium cyanide with three parts by weight of finely powdered sodium bicarbonate, scattered on the paths of the houses at dusk at the rate of 1oz. to every 1,000 cu. ft. of space. The advantages over the old jar method are that with the new method the gas is generated slowly, there is less risk of damage to the plants, and the cost is considerably less. All the adult flies were killed, but the same amount of cyanide used in the jar method killed a slightly higher percentage of nymphs. The plants, however, were slightly scorched. J.R.W.J.

Virus Disease of the Potato; Methods for investigating the—and some results obtained by their use.

MURPHY and MCKAY. *Scientific Proceedings of the Royal Dublin Society, New Series*, XVIII, No. 14, January, 1926.

Successful transmission of diseases of the mosaic type, and rare transmission of leaf-roll, was achieved by grafting a cone from a diseased tuber to another tuber. The capsid, *Calocoris norvegicus*, was again found to transmit leaf-roll.

The authors' experiments show that negative results with any particular insect cannot be accepted as proof that the insect is not a vector. A method is described by which the rate of spread of a virus in the potato plant can be ascertained. Leaf-roll virus, transmitted by grafting diseased scions on to the tops of stems of healthy plants, reached all parts of the plants in eight to fifteen days. J.R.W.J.

Willow Beetles; Experiments on the Control of.

LEES. Annual Report, *Agricultural and Horticultural Research Station, Long Ashton*, Bristol, 1924.

The author describes the results of laboratory experiments on the control of the willow beetles Galerucella and Phyllodecta. Of the several sprays tested, nicotine sulphate at the rate of 30oz. to 100 gallons of spray was the most successful, giving a 100% kill. A lead arsenate spray, 8lb. powder per 100 gallons, with the addition of 1% casein spreader, gave a 74% mortality. J.R.W.J.

GENERAL.

Abstractor:

PROFESSOR J. J. GRIFFITH, B.Sc., University College, Aberystwyth.

Research and the Land.

V. E. WILKINS, B.Sc., Ministry of Agriculture; published by H.M. Stationery Office. Prices: In paper covers, 2/6 net.; In cloth, 3/6 net.

This is the second of a series of publications issued by the Ministry of Agriculture with a view to enabling farmers and others to acquaint themselves with recent developments in agricultural and horticultural science. The present volume comprises a resumé of research work conducted during the past four years at all the research institutions and advisory centres of the United Kingdom. It provides, in a particularly interesting and readable form, an account of the efforts made by scientific workers to solve the many problems which arise in connection with all lines of farming and gardening practice. There are at least two things which are at once evident even to the casual reader of this book. Firstly, that Mr. Wilkins has been remarkably successful in providing a record of scientific investigations in non-technical language that may be readily understood by any intelligent layman. Secondly, that both the volume and the variety of research work conducted in agricultural science have increased immensely during recent years.

The following brief outline of the contents of the volume may suffice to indicate its importance and value to all agriculturists and horticulturists who have any desire to keep in touch with current research work.

Of the thirty chapters the first seven deal with soils and manures. Very clear indications are provided of the need for us to revise many of our views in reference to tillage operations and the action of fertilisers.

In Chapters VIII to XIII it is shown how the plant breeder, as the result of much tedious work, is making steady progress with the work of turning out new varieties and strains of cereals, potatoes, roots, herbage plants and fruit trees. Many new varieties are being produced by hybridisation. It is shown that many old native varieties which provide exceedingly good crops in certain districts are often found to be mixtures of a number of distinct types, and efforts are made to select the best types and grow them on as pure lines. Much work is also being done to ascertain the relative resistance of different varieties to various diseases.

In the next section, comprising Chapters XIV to XVIII, a very comprehensive account is given of what a number of investigators have achieved in their researches on the application of electricity to crops, the production of market garden and orchard crops, and the preservation of fruit and vegetables.

There are three chapters devoted to investigations conducted with a view to providing new methods for combating diseases and pests of farm and garden crops.

Problems relating to the breeding, feeding and management of live stock are dealt with in a very interesting manner in Chapters XXII to XXV. A particularly lucid account is given of several researches of fundamental importance. This section should be very carefully read by all stock-owners who take some interest in the improvement of any type of farm live stock.

The remaining chapters have reference to work done and investigations in progress in connection with milk and its products, animal diseases, agricultural engineering and agricultural economics.

In practically all sections of the book there is much that should be of particular interest to Welsh farmers. Special consideration is given to work conducted at Bangor in connection with the following:—soil survey; virus diseases of potatoes; diseases of swedes and mangolds; improvement of wool of Welsh sheep; Liver Rot in sheep. Similar reference is made to the following lines of research in progress at Aberystwyth:—the improvement of the local Hen Gymro wheat; the breeding of white winter oats; investigations relative to the improvement of herbage plants and the management of grassland in general; effect of climatic conditions on plant growth; studies bearing upon the nutritive value of hay and pastures under various conditions; cost of production of various farm commodities; economy of use of horse and manual labour on farms; survey of farm marketing, particularly marketing of eggs and butter, in Wales.

In an appendix, information is given regarding Advisory Centres and Research Institutions in the United Kingdom. In another appendix will be found a list of papers dealing with agricultural and horticultural research which have been published during the period under review.

It is very rarely that one comes across a scientific book which meets so well the requirements of the practical man and of the student of applied science alike.

Farmers and gardeners who read this work carefully will have a very clear conception of the manner in which the man of science is solving the problems of the man of practice. They will also perceive that, in the future, the development of improved methods of farming and gardening will be largely dependent upon the proper prosecution of research and the proper application of the results thereby obtained. J.J.G.

LIVE STOCK.

Abstractors:

J. A. Fraser Roberts, M.A., B.Sc., F.R.S.E., University of Edinburgh and University College, Bangor; and A. D. Buchanan Smith, M.Sc., University of Edinburgh.

Cows; On the Presence of Supernumerary Mammary Glands in—and on their Functional Activity.

Mackenzie, K. J. J., and Marshall, F. H. A. *Jour. Agric. Sci.*, Vol. 15, No. 1, pp. 30-35, 1925.

In the cases examined glands were associated with the supernumerary teats. Tests of the lactose content of the urine during lactation indicated that the milk which was being secreted by the supernumerary glands was being resorbed into the blood. J.A.F.R.

Cows; Ovarian Implantation in Presenile.

Staheli, A. *Schweit. Arch. f. Tierheilk.*, Vol. 82, 1925.

With a view to regenerating aged dairy cows in order to increase and prolong lactation, the reproductive organs of young heifers were grafted on to fifty-one aged cows. Thereafter, although most of the cows had refused the bull for nearly a year, forty-six came in season and were mated. Of these thirty-one conceived, while fifteen were mated again and produced a second crop of calves.

The technique of the operation appears to be fairly simple. No reference is made, however, to the comparative milk yields before and after the graft. A.D.B.S.

Eine exakte Prüfung der relativen Fleisch—und Wollleistung beim Merino-Fleischschaf im Vergleich zum Ostpreussischen schwarzköpfigen Fleischschaf.

Völtz, W., and Tantzon. *Zeit. Tierz.*, Vol. 2, pp. 83-111, 1924.

Among other findings the authors claim that a calcium carbonate supplement in the diet of the sheep with which they experimented produced a considerable increase in wool production. J.A.F.R.

Ein fruchtbares Maultier.

Henseler, H. *Deut. Landw. Tierz.*, Vol. 29, No. 15, pp. 245-253, 1925.

The author describes a fertile female mule which was found at an Agricultural Experiment Station in Tripoli. She had produced four foals, two to stallions and two to jacks. These foals tended to resemble horses and mules respectively. One of the foals had been served several times by a stallion without success. J.A.F.R.

Fleece; The Cotted.

Roberts, J. A. F. *Jour. Text. Inst.*, Vol. 17, No. 3, 1926.

The cotted or matted fleece has been studied in this case in Welsh Mountain sheep. The matting is due to the shedding of some of the

wool fibres composing the fleece, the fine shed ends of such fibres becoming intertwined. The process takes place during winter and spring, but the great majority of cases occur during a limited period, which is probably about February. The tendency to produce a cotted fleece is largely constitutional, *i.e.*, is characteristic of the individual sheep. The proportion of sheep affected increases with age, and there are large variations in the number affected in the same flock in different seasons. The evidence points to variable factors which act during a susceptible period on sheep of varying individual susceptibility. J.A.F.R.

Holstein Cattle; Inheritance of Twinning in a Herd of.

LUSH, R. H. *Jour. Hered.*, Vol. 16, pp. 278-279, 1925.

Previous investigations are quoted to show that the percentage of twinning in dairy cattle is 0.98%. At the Kansas Experiment Station the twinning percentage in the Friesian herd was 8.84%, being nearly five times as great as that found in the other breeds at the same station. In the case of one sire actually one out of every five cows mated to him produced twins, and it is shown in general that twinning appears to be definitely a hereditary family characteristic. The age of sire and dam, the season of the year, and the producing ability of the dams appeared to be negligible factors. J.A.F.R.

Hybridatavismus bei der Kreuzung rot—und schwarzbunter Höllander mit braungrauem Alpenvieh und die Verzögerung seines Aufscheinens durch Kastration.

STAFFE, A. *Zeit. Tierz.*, Vol. 2, No. 2, pp. 179-203, 1921.

This paper deals with the coat colour of seventy-five F_1 animals produced by crossing black and red Friesians with brown Swiss cattle, and also with nine back crosses. The uniform colour of the Swiss Cattle was dominant to the spotting of the Friesians except for white spotting along the back. The F_1 calves were brown in colour at birth and changed gradually to a glossy black during 4-6 months in the case of the males and 6-9 months in the case of the females. Early castration of the males prevented this colour change. J.A.F.R.

Inbreeding and Relationship from Livestock Pedigrees; An Approximate Method for Calculating Co-efficients of.

WRIGHT, S., and MCPHEE, H. C. *Jour. Agric. Res.*, Vol. 31, No. 4, pp. 377-383, 1925.

The result of a statistical analysis of the Shorthorn breed by Wright and McPhee was abstracted in the last volume of this Journal. The present paper deals with the mathematical processes involved in the calculation of co-efficients of inbreeding, etc. J.A.F.R.

Inheritance of Horns, Wattles and Colour in Grade Toggenburg Goats.

LUSH, J. L. *Jour. Hered.*, Vol. 17, pp. 72-91, 1926.

The horned condition of goats behaves as a simple recessive to the polled condition and has no relation to sex. This is the same type of inheritance as is found in cattle and differs from that found in sheep. This conclusion confirms that of Asdell and Crew in a paper reviewed in the last volume of this Journal. Wattles are inherited as a simple Mendelian dominant, as is the case in pigs, and probably also in sheep.

The data presented do not permit of very definite conclusions as regards coat colour. Solid white is described as epistatic to most colours, as is also the case with black colour and a pattern of extensive white spotting.

J.A.F.R.

Kemp in the Fleece of the Welsh Mountain Sheep.

ROBERTS, J. A. F. *Jour. Text. Inst.*, Vol. 17, pp. T274-T290, 1926.

A rather fuller account of work that has been described previously in this Journal. In the same number there are articles on kemp by Duerden (Merino), Blyth (British breeds) and Hurst and King (Mohair).

J.A.F.R.

Mare; The Œstrous Cycle in the—and some Associated Phenomena.

SEABORN, E. *Anat. Rec.*, Vol. 30, pp. 277-287, 1925.

The œstrous cycle in the mare is stated to last twenty-four days, made up of four periods: anœstrum, eight days; proœstrum, three days; œstrum, three days; and metœstrum, ten days. Ovulation occurs towards the middle or end of the œstrous period. J.A.F.R.

Pig; Prenatal Death in the—and its Effect upon the Sex-ratio.

CREW, F. A. E. *Proc. Roy. Soc. Edin.*, Vol. 46, pp. 9-14, 1925.

It has been shown that a considerable prenatal death-rate is usual in the pig, the percentage of corpora lutea that are not represented by living offspring being as high as 25%—40%. The writer examined the reproductive organs of sows killed at different times during pregnancy and divided them into four groups according to the average weight of the fœtuses. The figures for litter size were 13.5, 12.2, 9.1, 7.1, and the corresponding sex-ratios 60.6, 59.8, 56.3 and 50.9. There is definite evidence, therefore, of a prenatal mortality that bears more heavily on the males and reduces the originally unequal sex-ratio to something very like equality at the time of birth. J.A.F.R.

Pig; The Seasonal Sex Ratio in the.

PARKES, A. S. *Zeit. indukt. Abst. Vererb.*, Vol. 40, 1926.

The data are based on the National Duroc-Jersey Record, vol. 67. The year was divided into quarters: September to November; December to February; March to May; June to August. Of 10,961 births recorded, 5,007 were males and 5,954 females for the whole year, giving a male percentage of 45.6. More than half these births occurred during the March to May quarter, but in spite of this no significant variation in the sex-ratio was found. The male percentages for this and the three successive quarters were respectively 46.1, 45.4, 45.2, 44.4. The author therefore concludes that in this breed of pig no seasonal variation in the sex-ratio occurs. A.D.B.S.

Recherches génétiques sur le porc monongulé.

MALSBURG, K. *Rozprawy biologiczne z zakresu medysyny weterynaeyjnej, rolnictwa, hodowli*, pp. 247-254, 1924.

The author describes breeding experiments with syndactylous (solid hoofed) pigs of the primitive Polish Polesie breed. The syndactylous condition behaves as a simple dominant. Syndactylism in swine is not

of infrequent occurrence, but apparently it is a regular feature of the breed described. This breed is piebald black and white, this pattern being recessive to white colour. J.A.F.R.

Sexual Physiology for Biological, Medical and Agricultural Students.

MARSHALL, F. H. A. 167 pp. Longmans, Green & Co., 1925.

This small book should be extremely valuable to those for whom it is written. Students who have not the time to study the author's larger work, "The Physiology of Reproduction," will find in the present volume the essentials of the subject given in a compact and lucid form. The only criticisms that could be made are that the chapter on the secretions of the organs of reproduction is rather dogmatic in relation to the controversial nature of some of the work discussed, and that the chapter on heredity and sex is not as adequate as the rest of the book. These are, however, small matters, and the book is certain to appeal to a wide circle of readers. J.A.F.R.

Sheep; Colour Inheritance in.

II. The Piebald Colour of the Piebald Breed.

ROBERTS, J. A. F. *Jour. Genet.*, Vol. 17, pp. 78-83, 1926.

The result of crossing Piebald sheep to other breeds is the production of self blacks only. Back crosses showed that Piebald sheep differ from other breeds in that they possess a dominant black factor and a recessive piebald factor. J.A.F.R.

Sheep; Fertility in.

NICHOLS, J. E. *Jour. Minist. Agric.*, Vol. 33, June, 1926.

The present paper amplifies the conclusions previously set forth by the author and reviewed in this Journal. Breed differences in fertility are largely of a hereditary nature and fertility varies in response to environmental conditions operating on this basis. A high proportion of multiple births and a low proportion of barrenness and abortion are the important factors. The practice of flushing tends to produce a high lambing percentage. J.A.F.R.

Sheep; Segregation in Halfbred.

NICHOLS, J. E. *Jour. Hered*, Vol. 16, pp. 401-408, 1925.

It has frequently been asserted that Halfbred (Border Leicester-Cheviot) sheep "breed true" in the sense that F_1 animals mated together do not show the evidences of segregation that might be expected and that in fact their offspring are as uniform as the offspring of an ordinary pure breed. The author examined a large flock of F_2 Halfbreds and found distinct evidence of segregation, particularly as regards fleece characters and body and head conformation. In the F_1 generation some variation existed and in the F_2 generation the parental types appeared. As regards general body conformation this is certainly multifactor, but the small height-length ratio of the Border Leicester appeared to be incompletely dominant to the larger one of the Cheviot. There are indications that the less aquiline profile of the Cheviot is partially dominant to the more aquiline profile of the Border Leicester. The Cheviot frill shows almost complete dominance. The conclusion, therefore, is that the popular belief cannot be substantiated. J.A.F.R.

Southdown Sheep; Fertility in.

NICHOLS, J. E. *Jour. Agric. Sci.*, Vol. 16, pp. 365-375, 1926.

A statistical study is presented of the lambing results from twenty-six flocks including 5,014 ewes. The relatively low fertility of shearling ewes is due to barrenness which is undoubtedly caused by reduced or delayed ovulation. The proportion of twinning is closely associated with the total yield of lambs. Those factors that cause abortion also affect the yield by reducing the number of single births rather than the number of multiple births. J.A.F.R.

Stallions; On the Fertility of.

SANDERS, H. G. *Jour. Agric. Sci.*, Vol. 16, pp. 466-491, 1926.

This paper is a statistical analysis of sets of records for light and heavy horses with the object of studying some of the factors, which affect the percentage of foals given by a stallion in a service season. An individual factor was found, i.e., there is a definite tendency for some stallions to be better breeders than others. The fertility of stallions is higher in the north and west of England and in Wales than in the south and east and especially than in Scotland. In moderation the effect of frequent use is not detrimental. After the age of sixteen years there is definite decline in fertility, which occurs over the whole range and is not due to some animals becoming completely sterile.

J.A.F.R.

Swine; Inheritance of Black in.

WARWICK, B. L. *Jour. Hered.*, Vol. 17, pp. 251-254, 1926.

Crosses are described between the Poland-China and Duroc Jersey breeds. The former breed is black with white points and the latter red. There were 181 F_1 pigs produced, all showing black spotting. The ground colour varied from white to red. F_2 and F_3 generations and a backcross were raised, and the numbers obtained fitted the hypothesis that the presence or absence of black is to be explained on the basis of a simple factor difference. J.A.F.R.

Swine; Unusual Coat Colours in.

MCPHEE, H. C., and ZELLER, J. H. *Jour. Hered.*, Vol. 16, pp. 347-350, 1925.

Intensive inbreeding was started by the U.S. Bureau of Animal Industry with several pairs of Poland-China, Tamworth and Chester White pigs. Brother to sister matings were practised. Although the original pairs were pure as far as the term means anything in relation to the various breeds, some peculiar colour combinations cropped up among the offspring. One line of Poland-Chinas gave pigs of a dilute black or sepia colour, having in addition the white points of the Poland-China and also numerous white spots over the body. This dilution factor appeared to be a simple recessive in contrast to the black of the Poland-China. Three sister Chester White sows mated to their brothers produced three pigs with red and black colour markings, the genetics of which are as yet obscure.

The authors emphasise the lesson that intensive inbreeding brings out the hidden recessive characters of a stock, characteristics that may remain hidden during many generations of outbreeding.

J.A.F.R.

Uber die Scheckung des schwarzbunten Niderungsrindes und ihre Vererbung.

LAUPRECHT, E. *Zeit. f. indukt. Abst. Vererb.*, Vol. 40, pp. 139-196, 1926.

A study of the inheritance of spotting in three large herds of Friesian cattle in Holland and North Germany. The author states that there are six definite centres of white: above the eye and cheek, above the ear and back of head, the neck, the upper portion of fore leg, the middle region of the body around the last ribs, and the hocks of the hind legs. After a lengthy explanation and description he comes to the conclusion that a mating of two dark Friesians will not produce a light one, while a mating of two light ones will not produce a dark one, although medium-spotted individuals are produced in all cases. This serves to confirm the view of several other investigators that the inheritance of spotting in the Friesian is due to multiple factors. There is no evidence that sex in any way affects the markings. A.D.B.S.

Untersuchungen der Cuticula pilis bei verschiedenen Schafrassen als Rassenmerkmal.

HOFFMANN, K. *Jahrb.*, 61, pp. 763-778, 1925.

It was found that breed differences occur as regards the number of cuticular scales in relation to the length and diameter of the wool fibres. The average area of fibre covered by the overlapping portions of the cuticular scales was calculated in microns as follows: Leicester, 662; Southdown, 478; Escurial, 379; French Merino, 377; Rhön, 339; Hampshire, 276. J.A.F.R.

Untersuchungen über Variation und Vererbung des Gesauges beim Schwein.

NACHTSHEIM, H. *Zeit. f. Tierz. u. Zucht.*, Vol. 2, No. 2, pp. 113-161, 1924.

Gesaug—und Schweinanzahl.

NACHTSHEIM, H. *Deut. Land. Tierz.*, Vol. 29, No. 21, pp. 345-349, 1925.

The writer studied 1,000 offspring of eight boars, the numbers of mammae being known for the parents in each mating. There was much variability, the average number for the offspring being 12.97. The writer is of the opinion that seven pairs is the normal number, the second and sixth pairs showing greater variability in their presence or absence than the other pairs. Either or both of the mammae in these pairs may be present, absent, or rudimentary, while additional teats may occur either singly or in pairs between the others. It is thought that the number in the male is as important as that in the female in determining the characterisation of the offspring.

Little relation has been found between the number of mammae and fertility, this finding being in accordance with the results of Graham Bell with sheep. J.A.F.R.

Vererbung eines steifen Wollbüschels auf dem Kreuz des Schafes.

WRIEDT, C. *Zeit. Tierz.*, Vol. 8, pp. 241-242, 1925.

The author describes two rams which possessed a stiff tuft of coarse hair on the rump. Twenty-three offspring included eleven that possessed this feature. It is concluded, therefore, that it behaves as a simple Mendelian dominant and that both rams were heterozygous.

J.A.F.R.

Vererbung von Backenflecken mit schwarzen Haaren bei norwegischen Westlandpferden.

WREIDT, C. *Zeit. Tierz.*, Vol. 3, pp. 239-240, 1925.

The author during a study of the stud books of Westland horses found in a number of individuals the presence of spots on the face, the spots being covered with dark hairs which are brown in chestnut, cream and creamy dun horses, and black in grey horses. All the progeny of a stallion assumed to be homozygous exhibited the character, and three heterozygous sires gave twenty-four offspring with the spots and twenty-six without. It is concluded, therefore, that this character is based on a single dominant Mendelian factor. J.A.F.R.

Vererbung von weichen und harten (steifen) Haaren im Gesichte des Schafes.

WRIEDT, C. *Zeit. Tierz.*, Vol. 3, No. 2, pp. 231-234, 1925.

The Rygja breed of sheep possesses soft hairs on the face, especially on the back of the nose, while other breeds of the same district have stiff hairs on the corresponding areas. Breeding experiments with seven rams of the Rygja breed showed that the genetic difference was a simple one, soft hair being dominant to stiff hair. J.A.F.R.

PLANT PATHOLOGY.

Abstractor: T. WHITEHEAD, M.SC., PH.D., University College, Bangor.

Apple Scab; Biological Observations on.

E. S. SALMON and W. M. WARE. *Journ. Pomology*, Vol. 4, 1925, p. 230.

The discovery of the winter or perithecial fruit bodies previously reported by the authors provided a likely explanation of early outbreaks of scab, and so reduced the necessity for searching for the nearest scabbed wood, which, until recently, was regarded as the only means in this country by which the disease could persist from one season to another. Evidence is submitted to show that Cox's Orange Pippin, Worcester Pearmain and Bismark were readily attacked early in the season of 1924, whereas Newton Wonder, Beauty of Bath, Bramley's Seedling, Lane's Prince Albert and Annie Elizabeth were more resistant. Observations made prove that a heavy infestation of the foliage does not necessarily lead to the infection of the young wood. The attention of growers is drawn to the need for spraying *before* the blossoms open, at any rate on the more susceptible varieties, since the disease occurs on the very young leaves at this time and failure to spray them may render subsequent attempts to arrest the disease futile. T.W.

Potato Blight. Occurrence of diseased shoots arising from tubers infected by Phytophthora infestans.

E. S. SALMON and W. M. WARE. *Ann. Appl. Biol.*, Vol. XIII, 1926, p. 289.

An experiment is recorded in which of twenty-five naturally infected tubers planted early in April in pots in the greenhouse, two produced by May 16th short diseased shoots, which developed conidiophores and spores. These shoots were regarded as infected *ab initio* by mycelium growing from the tuber, and it is pointed out that in appearance they

closely resembled those described by de Bary and other investigators. A probable case of secondary infection was observed on a leaf on one of the healthy shoots of a plant which produced a diseased shoot.

T.W.

Potato Leaf-Roll. A Method of diagnosing "Primarily" Infected Tubers.

W. McLean. *Journ. Agric. Science*, Vol. XVI, 1926, p. 149.

On drying at laboratory temperature (about 60° F.) healthy tubers lose weight to a much greater extent than those which were infected with leaf-roll in the current season; the former become soft and flabby, whilst the latter remain hard even after sprouting. It is suggested that healthy seed may be separated from primarily infected seed on this basis.

T.W.

Potato Leaf-Roll. Effect of Leaf-Roll on the composition of the tuber and "mother" tuber.

W. McLean. *Journ. Agric Science*, Vol. XVI, 1926, pp. 318-324.

One effect of leaf-roll in its secondary form is to reduce the percentage of dry matter in the tubers, whilst that of nitrogen in dry matter is appreciably higher than in tubers derived from healthy plants. The rate at which nutrient materials are removed by the young plants from the mother tubers is much slower than in the case of plants from healthy stock. T.W.

Potato Wart Disease; Further Experiments on the use of Sulphur in relation to.

W. A. Roach and W. B. Brierley. *Ann. Appl. Biol.*, Vol. XIII, 1926, p. 301.

Continuing their work on the control of wart disease, the previous results of which seemed to indicate that a feasible method of eradicating the disease had been found in the application of sulphur, the writers laid down further trials in contaminated soil during 1925. At Ormskirk plots of light sandy soil were treated with sulphur at rates of 10cwt. and 15cwt. per acre, thorough incorporation being ensured by the use of a Simar Rotary Tiller. A planting of King Edward and a replanting of Arran Chief in the treated plots almost completely failed to grow. On the few plants which developed, wart disease was present in less quantity than on the plants in the untreated controls. A plot of heavy clay soil at Hatfield was similarly treated with three tons of sulphur per acre. On this plot plants of King Edward grew well but showed a considerable amount of wart disease. Plots of land at Ormskirk, which in 1924 had received amounts of sulphur varying up to one ton per acre, were in 1925 given a dressing of lime and planted with Majestics. No effect of the previous treatment on the crop was apparent. T.W.

Raspberry; Blue Stripe Wilt of.

R. V. Harris. *Journ. Pomology*, Vol. 4, 1925, p. 221.

A disease of cultivated raspberry causing a wilting and death of the canes, progressing from below upwards, is described. During the winter the dead fruiting canes and shrivelled buds are the only evidence of disease, but these become conspicuous in spring amongst the healthy canes. In some cases the canes produce only small leaves and under-

sized fruit, whilst in others the cane dies before the fruit matures. On the new canes symptoms appear rather late in the season, the first sign being found on the lower leaves. The tissues between the veins become yellow or red-brown and wither; sometimes the leaves curl up at the margin and fall prematurely, the terminal tuft being the last to survive. A blue stripe on the stem, extending from the ground upwards, is regarded as the most reliable symptom. Inoculations have shown that a species of verticillium, isolated from diseased canes, will reproduce all the symptoms in healthy canes. Work on possible means of control is in progress. T.W.

Silver Leaf Disease.

F. T. Brooks and W. C. Moore. *Journ. Pomology*, Vol. 5, 1926, p. 61.

In continuation of their work the authors have obtained valuable data on the incidence of silver leaf and on certain methods of control. They call attention to a slight increase of the disease on roses, especially ramblers. The spores of *Stereum purpureum* can infect *fresh* wounds readily throughout the year except during June, July and August. It is difficult for the fungus to infect wounds of more than a month's standing, and practically impossible for it to infect tissues which have been exposed for three months. Growers are urged to cut out dead wood and silvered branches (when the latter is advisable) during the early part of the summer, at which time, also, the thinning of fruit trees should be done. The amount of natural recovery from this disease is greater than was formerly supposed, even in susceptible varieties of plums, such as Victoria and Czar, the amount of natural recovery being correlated with the vigour of the tree. As protective substances gas tar and Stockholm tar have proved unsatisfactory, and formulae are given for making paints of a certain consistency which appear to have advantages over the tars; good results have been obtained with soft grafting wax. The authors record the results of ring-barking silvered trees and state that there is no evidence that any considerable benefit is likely to accrue from this treatment. T.W.

Silver Leaf; Notes on.

F. R. Petherbridge. *Journ. Pomology*, Vol. 5, 1926, p. 141.

The author records observations made since 1919 in the orchard belonging to Mr. Afford, of Bluntisham, who has had considerable success in reducing the loss caused by silver leaf infection. In this orchard the greatest natural recovery took place during the dry period of 1921-22, during which time, also, the " cut " trees showed the greatest freedom from silvering. Mr. Afford's success appears to be due partly to the fact that the silvered branches are always removed before the middle of May and to the methods adopted for removing them. Whenever possible the silvered branch is cut back to a healthy lateral, but where no healthy laterals are present on the branch it is not cut back to the trunk but only sufficiently far as to leave one or two feet of stump—providing that the end of the stump shows no dark stain in the wood due to fungus. This " hat-peg " method of pruning allows the stumps to send out adventitious shoots which will quickly build up the part of the tree that has been removed. The ends of the stumps are not covered with any preparation to prevent the entrance of the silver leaf fungus.

Up to 1919 Mr. Afford always planted apple trees in place of diseased plums which were removed, it being the general opinion of growers that it was unwise to put a young plum in the ground from which a silvered plum had been taken. In 1920, however, Mr. Afford replaced a number of such diseased plums with twenty-two young Czar plums. None of these trees has died and only one has shown silvering. The conclusion is reached from this and other observations that there is very little danger of the young plum becoming infected from the previous tree, provided the latter is removed and burnt. The author is of the opinion that losses from silver leaf can be reduced by working Victorias on common plum stock instead of on Myrobolan stock. T.W.

Tomato. Some Nutritional Disorders.

W. F. Bewley and H. L. White. *Ann. Appl. Biol.*, Vol. XIII, 1926, p. 323.

The authors summarise data on the causes of irregular ripening of tomato fruits obtained during the last five years. They show that blotchy ripening is the result of malnutrition in respect of potash and nitrogen, especially the former. Phosphates seem to be unimportant in this respect. The proportion of such blotchy fruits may be reduced to less than 1% by suitable applications of sulphate of potash and sulphate of ammonia, but it is pointed out that blotchy ripening has not been eliminated entirely by manurial treatment. Other factors, probably climatic in nature, play some part in the incidence of this disorder. Exposure of the fruit to excessive sunlight causes a type of blotchiness called " green back " if the nitrogen and potash supply is inadequate. The leaves of tomato plants grown in soil deficient in nitrogenous foods develop pale yellow blotches between the veins. The blotches increase in size until the whole leaf is yellow. Leaf scorch, characterised by a paling and subsequent dessication of the leaf margin, is due to potash starvation and can be eliminated completely by the application of sulphate of potash. Root invading fungi, such as *Collatotrichum tabificum*, interfere with the feeding of the plant and indirectly cause blotchiness of the fruit. T.W.

SOILS AND MANURES.

Abstractor: Rice Williams, M.Sc., University College, Bangor.

Ammonium Nitrate; Physiological Characteristics of.

D. V. Pryanizchnikov. *Z. Pflanz. Düng.*, 1925, No. 4, A, 242-250.

Studies on the assimilation by plants of ammonia and nitrate from ammonium nitrate showed that the ammonia was more extensively and rapidly assimilated than the nitrate, and that ammonium nitrate is therefore essentially a physiologically acid fertiliser. R.W.

Applications of Nitrogen, Potash and Phosphate on Different Crops; The Effect of Simple and Increasing.

O. Nolte and R. Leonhards. *Z. Pflanz. Düng.*, 1925, 4B, pp. 286-306.

A review of numerous fertiliser experiments conducted in Germany and Denmark is given. By comparing the increase of crop yield for a unit of the fertilising element (1 kg of N, K_2O, and P_2O_5) the authors find a variation in the effect, particularly of the nitrogen fertilisers for various parts of Germany and Denmark. They explain this variation

by difference in climate, length of day, etc. A review of comparative results on various crops fertilised with sodium nitrate, ammonium sulphate and calcium nitrate showed that sodium nitrate and ammonium sulphate were alike in increasing crop yield, while calcium nitrate was often not as effective as the other forms of nitrogen. From the results with increasing applications of nitrogen fertilisers it was concluded that an application of over 60 kg of nitrogen per hectare would not be profitable.

R.W.

Applying Fertilisers; Effects of Various Methods of—on Certain Crops and on Certain Soil Conditions.

D. G. Coe. *Soil Science*, 1926, 21, pp. 7-21.

A thorough study was made of the effect of applying different fertilisers in various amounts upon the germination, top growth, root development of crops, and upon the movement of the fertilisers. Phosphatic fertilisers were the least toxic to plants, but when applied in direct contact with the seed even it was toxic when used at the rate of 300lb. per acre. Nitrate of soda and chloride of potash at the rate of 25lb. per acre retarded germination. Placing the fertiliser one inch to the side of the row of seed gave better returns than applications a similar distance above or below the seed, because of the fact that the lateral diffusion of salts is much slower than the vertical diffusion. The side application is recommended for all localised fertilisers treatment.

R.W.

Basic Slag; Effect of Dressings of—on the Lime Status of Soils.

Rice Williams. *J. Agric. Sci.*, 1926, 16, pp. 196-204.

The free and combined lime contained in basic slag appears to be equally efficient with that of calcium carbonate or lime in maintaining or improving the lime status of soils. For example, a dressing of 10cwt. of slag containing 50% total CaO should be approximately equivalent to 5cwt. of lime in its effect on soil acidity. R.W.

Carbon Dioxide Content of the Soil Air; The—as a Factor in the Absorption of Inorganic Elements by Plants.

F. W. Parker. *Soil Science*, 1925, 20, pp. 39-44.

The results of experiments on the influence of the removal from the soil air and the addition to it of carbon dioxide are reported. It was found that the removal from the soil air or the addition to it of carbon dioxide did not materially influence the crop yield. R.W.

Carbon Dioxide Fertiliser.

Gerlach and Seidel. *Z. Pflanz. Düng.*, 1925, 4, B, 241-247.

Tests on a so-called carbon dioxide fertiliser containing 30% of peat, 15% of carbonaceous material and 5% of a so-called catalytic material are reported. No increases in crop yields were obtained with this material which could be attributed to its content of organic matter, and in some cases the yield of lupines was decreased. R.W.

"Clumina"; The Italian Fertiliser.

P. Ehrenburg. *Z. Pflanz. Düng*, 1925, 4B, pp. 218-215.

"Clumina" is an earth saturated with chlorine gas in an attempt made to use chlorine gas used for the preparation of war gases.

" Clumina " is supposed to make available the organic nitrogen of the soil by its sterilising action followed by a stimulation of microbiological processes. Pot experiments were not conclusive. R.W.

Disaggregated Phosphates in Belgium.

J. GRAFTIAU. *Chem. et Indus. (Paris)*, 1924, Spec., No. 678-683.

Experiments conducted at different Belgian Experiment Stations with disaggregated (presumably treated in such a manner as to change the phosphate into the di-calcium phosphate) phosphate, such as Vesta and Supra phosphates, are reported. Their fertilising value is generally correlated with their solubility in ammonium citrate solution. But certain of these phosphates which were only 50% citrate soluble were as high in fertilising value as higher grade phosphates, the phosphoric acid content of which was 90% citrate soluble. R.W.

Lime Applications; The Injurious Effect of Excessive.

A. F. TYULIN. *Trans. Inst. Fertilisers (Russia)*, 1923, 18, 3-15.

Excessive liming brings about an alkaline reaction, an increase in the amount of soluble calcium salts, and as a result nitrates and, at times, ammonia appear in the early stages. Either factor by itself is not of great importance in soil reactions, but a disturbance in nitrification and activation of denitrifiers is of importance. R.W.

Limes, Marls, and some Calcium and Magnesium Compounds; Action of—on Cultivated Soils.

A. GEHRING and C. SCHULCKE. *Z. Pflanz. Düng.*, 1925, 4, No. 3, B, 113-139.

The results indicate that the influence of liming on the physical properties of the soil is of greater importance than that on the chemical properties. The physical properties were found to undergo profound changes under the influence of liming, which in turn largely control the intensity of the biological changes. R.W.

Limestone and Dolomite Separates; The Decomposition of—as Influenced by Zone of Incorporation.

W. H. MACINTIRE and W. M. SHAW. *Soil Science*, 1925, 20, pp. 403-415.

A report of a four year lysimeter study of carbonate decomposition as influenced by (*a*) fineness and (*b*) zone of incorporation is given. For all practical purposes it may be said that both limestone and dolomite of 80-200 mesh fineness were completely decomposed in both surface and sub-surface zone; but for the coarser separates the limestone showed greater decomposition than the corresponding dolomite separate. All these separates showed a greater decomposition in the sub-surface zone than in the surface zone. R.W.

Nitric Nitrogen and Ammoniacal Nitrogen in the presence of partial sterilisation; Comparative tests of—on crop yields.

G. RIVIÈRE and G. PICHARD. *Compt. Rend. Acad. Sci. Paris*, 1925, 180, 13, pp. 1,054-1,056.

Ammonium sulphate, when used with salts producing partial sterilisation of soil, gave better crop yields than ammonium sulphate alone or sodium nitrate alone. This is attributed to the increased nitrification immediately following partial sterilisation. R.W.

Nitrogen; The Availability of—in Nitrate of Soda, Ammonium Sulphate and Dried Blood when the Amounts of Phosphoric Acid and Potash are varied.

A. W. BLAIR and A. L. PRINCE. *Soil Science*, 1925, 9, pp. 467-476.

The results of studies are reported on the availability of nitrogen in the forms of nitrate of soda, sulphate of ammonia, dried blood, and the three materials in combination, when the amounts of potash and phosphoric acid are varied. Taking a three year average of the rape crops there was a slight increase in nitrogen with increase in the amounts of phosphoric applied. For the same period, using a double portion of potash, there was only a slight change in nitrogen recovery. With rape, nitrate of soda gave largest yield and highest nitrogen recovery, while dried blood gave the lowest. R.W.

Nitrogenous Fertilisers; Use of.

BRETIGNIÉRE, VERCHÉRE and CARTIER. *Compt. Rend. Acad, France*, 1925, 11, No. 3, pp. 91-95.

Comparative test of ammonium chloride and urea with sodium nitrate and ammonium sulphate on root and cereal crops are briefly reported. In general the best results were given by sodium nitrate, while ammonium sulphate and ammonium chloride were about equal in value for cereals. The chloride was superior for root crops. Urea gave results almost as good as those given for sodium nitrate, but was more difficult to use in proper amounts. R.W.

Nutrients; The Fertiliser—required by Barley, Wheat and Oats, as shown by Soil and Water Cultures.

R. L. JONES and F. R. PEMBER. *Soil Science*, 1925, 19, No. 3, pp. 169-199.

The results of studies conducted at the Rhode Island Experiment Station on these three cereals are reported, the media used being nutrient solutions and a mixture of soil and sand. The amounts of potash and nitrogen required by these three cereals when grown in the different media were small. The difference in the amounts of phosphoric acid required for the optimum growth of the cereals in both soil and water cultures was the principal point of dissimilarity. The dry matter from the water culture contained only about one-third to one-half as much phosphoric acid as the dry matter of the soil cultures of the cereals under similar conditions. The straw-grain ratio was found to be greater in the plants from the water culture series than in those from the soil culture series. R.W.

Nutrients; To what Depth can Plants Efficiently Assimilate?

O. LEMMERMANN, H. WIESSMANN and K. ECKL. *Z. Pflanz. Düng.*, 1925, 4, No. 6, B, pp. 233-251.

Studies are reported which showed that plants are able to assimilate nutrient materials from rather deep soil strata in amounts sufficient to influence yields. In general, subsoils do not contain as much organic matter, nitrogen, phosphoric acid and potash as the cultivated surface soils, but usually are better supplied with lime. There are so many exceptions to this rule, however, as to indicate the importance of studying both the surface and the subsoils when determining the total nutrient supply of the soil. R.W.

Permanent Grassland.

F. E. Corrie. *Fertiliser, Feeding Stuffs and Farm Supplies Journal,* 1926, 11, pp. 127-131.

Phosphatic fertilisers increase the nitrogen content of pastures by promoting the growth and development of clover and other legumes. The nitrogen content of a pasture soil receiving phosphates alone over a period of eleven years was increased by 0.05%, while another plot receiving sulphate of ammonia and nitrate of soda in addition to phosphates contained 0.04% less than the control. Grass from the pasture plot fertilised with basic slag and lime contained an average of 1.5 times as much calcium oxide over a period of six months as grass from the control plot. The value of mineral compounds in animal nutrition is also discussed. R.W.

Phosphoric Acid; Losses of—by Leaching from Upland Soils in N. Wales.

G. W. Robinson and J. O. Jones. *Agric. Progress,* 1926, 3, pp. 39-42.

Under typical N. Welsh conditions, poor pastures dressed with basic slag tend to revert to their original phosphate status after six to eight years, the added phosphate being washed down in percolating waters. It thus appears necessary to renew slag dressings every five or six years in order to maintain improvement in such cases. R.W.

Residual Effects of Forty Years' Continuous Manurial Treatments.

II. Effect of Caustic Lime on Soil Treated with Farmyard Manure.

Soil Science, 1925, 20, pp. 313-327.

The results of studies on two manured plots at the end of forty years' treatment are reported. During this period both plots received 120 tons per acre of farmyard manure, and in addition one plot received twenty tons per acre of burnt lime. A greater amount of dry matter was obtained from the soil treated with lime and manure than from the soil treated with manure alone during the forty years. At the end of this period the lime treated soil contained greater amounts of organic matter and nitrogen and showed a gain of 508lb. of nitrogen per acre (2,000,000lb.) in excess of the untreated soil as compared with 214lb. when manure alone was used. The lime applied to the land stimulated the decomposition of organic matter, thus causing a sufficient increase in crops to cause an accumulation of organic matter from crop residues in excess of the manure treatment without lime. Data are also given showing the amount of humus soluble in alkali solutions. R.W.

Silica; Investigations on the Cause of the Yield-increasing Action of.

O. Lemmermann, H. Wiessmann and K. Sammet. *Z. Pflanz. Düng.,* 1925, 4, No. 5, A, pp. 265-315.

Silica can produce important increases in crop yields only when there is a deficiency of available phosphoric acid in the soil. No direct growth-promoting properties of silica can be demonstrated. The cause of the favourable action of silica is apparently due to the bringing about of an increased assimilation of phosphoric acid by plants. This increased utilisation of phosphoric acid by plants in the presence of silica is attributed to the dissolving action of the silica on phosphate compounds and not to a modification of plant functions. R.W.

Straw; Effect of—on Accumulation of Nitrates and Crop Growth.

T. L. MARTIN. *Soil Science*, 1925, 20, pp. 159-164.

The results of experiments carried out on a loam soil common to Utah show that wheat straw is detrimental to nitrification and to the growth of crops, at least, for a period. There is a desirable residual effect. The principal harm seems to be due to the retarded accumulation of nitrates in the soil. It is suggested that the nitrates in the presence of a large supply of carbonaceous matter are probably utilised by the increased number of bacteria that tend to accumulate in the presence of a large supply of straw. After a period a new supply of nitrogen accumulates in the soil, then further decomposition of straw ensues, the organic carbon is used up, and the by-products of decay together with a narrower C/N ratio create an environment more favourable to crop productivity. R.W.

Straw Mulch; Nitrate Accumulation under.

W. A. ALBRECHT and R. E. UHLAND. *Soil Science*, 1925, 20, pp. 253-265.

Experiments carried out at the University of Missouri indicate that the straw mulch, in applications as heavy as six tons to the acre, cuts down evaporation, thereby increasing the moisture, lowering the temperature, and preventing the normal exchange of air, all of which induce a poor physical condition and an unfavourable environment for nitrate accumulation. R.W.

Subsoil Potash; The availability of.

S. B. HASKELL. *Soil Science*, 1925, 19, No. 2, pp. 105-114.

The results of pot experiments carried out at the Massachusetts Experiment Station with subsoils from five sandy loams are reported. It is shown that potash in these subsoils is sufficiently available to give maximum production, and that the potash in the deeper subsoils is either more rapidly available or present in greater quantity than in the more shallow subsoils. The data also confirm the fact already established that the amount of potash in the plant at harvest time may not bear any definite relation to the amount actually required by the plant.

R.W.

Timothy and Clover Residues in the Soil; An Explanation for the Relative Effects of—on Nitrate Depression.

R. D. WILSON and J. K. WILSON. *Cornell Univ. Agr. Expt. Stat. Memoir*, 1925, 95. pp. 1-21.

The roots of clover and hay were completely oxidised in the soil in less time than were those of timothy; this is due to the greater nitrogen content of the former. The evolution of carbon dioxide was directly proportional to the bacteria counts from the soil containing clover and timothy. The soil organisms are believed to remove soluble nitrates from the soil solution to be returned again when their bodies are decomposed.

R.W.

Tri-Calcium Phosphate and Phosphates of Aluminium and Iron; Comparative Assimilation of.

C. BRIOUX. *Chem. et Indus. (Paris)*, 1924, Spec. No. 687-690.

Aluminium phosphate was slightly superior to tri-calcium phosphate in the production of dry matter, and markedly superior with reference

to assimilation of phosphorus by crops. Iron phosphate was less available to crops than either calcium or aluminium phosphates, although it was utilised to a considerable extent by barley and buckwheat. R.W.

Turnips; Effect of Increased Fertilising on.

A. JACOB. *Z. Pflanz. Düng.*, 4B, 1925, pp. 156-161.

Results are quoted showing that P_2O_5 or N may be a limiting factor in turnip cultivation. With N and K_2O it is shown that up to a limit a slight excess of one may overcome a deficiency of the other. Crops treated with a fertiliser containing potash always show a high yield of dry matter and sugar. This and the cheapness of potash compared with other fertilisers in Germany indicates that a fertiliser with a high potash content is the best for economical cropping of turnips. R.W.

Urea; Some Properties of—with Reference to Soils.

F. COUTURIER and S. PERRAUD. *Compt. Rend. Acad. Agr. France*, 1925, 11, No. 16, pp. 492-496.

Studies are reported showing that soils do not absorb urea but that it is transformed quite rapidly in soils into ammonium carbonate by biological action. The rate is practically proportional to the time of contact and markedly affected by temperature. The results are considered to have an important bearing on the use of urea as a fertiliser, owing to the possibility of nitrogen losses as ammonia when used unseasonably. R.W.

VETERINARY SCIENCE.

Abstractor: NORMAN BISSETT, M.R.C.V.S., University College, Cardiff....

British Sheep; Some Parasites of—with some suggestions for their eradication and control.

By WILLIAM C. MILLER, M.R.C.V.S., and published by Robert Young & Co., Ltd., 38, Elliot Street, Glasgow. Price 2/6.

This is an excellent and very readable publication, the photographic illustrations alone being extremely useful. The book is written in non-technical language, but this does not mean that it is of any less value to the parasitologist. On the contrary, it is a distinct recommendation. The section on " Dipping " should be marked, learned and inwardly digested by every sheep-owner. The work deals chiefly with the insect and arachnid parasites of sheep and does not touch the helminthological aspect. The life history of each parasite and the methods of control in each case are give. Certain other specific diseases of sheep, apart from those due to parasites, are also dealt with. N.B.

Life-history of Limnaea truncatula; Further Observations on the.

C. L. WALTON, PH.D., M.SC., and W. NORMAN JONES, B.SC. *Parasitology*, Vol. XVIII, No. 2, July 16th, 1926.

Experiments conducted by the authors show that *Limnaea truncatula* is self-fertile, and that two and probably three generations occur between March and October. N.B.

Liver Fluke in Sheep; The Control of.

C. L. Walton, Ph.D., M.Sc., and W. Norman Jones, B.Sc. *Journ. of the Ministry of Agric.*, Vol. XXXII, No. 8, November, 1925.

Copper sulphate used as a spray, as a dust, and broadcast mixed with sand is successful in destroying *Limnaea truncatula*, the recognised host snail. The cost of these methods, apart from labour, was as follows:—

	Per acre.
Spraying	7/6
Dusting (copper sulphate combined with China clay, which acts as a carrier and also marks out the area treated)	12/6
Broadcasting (excluding cost of sand with which the copper sulphate is mixed)	10/-

N.B.

Nematode and Cestode Parasites of Sheep in North Wales, October, 1923, to September, 1924; A Preliminary Survey of the.

Nematode and Cestode Parasites of Sheep, Pigs and Cattle in North Wales, October, 1924, to September, 1925; A Further Survey of the.

W. Norman Jones, B.Sc. *Journ. of Helminthology*, Vol. IV, No. 1, March, 1926, pp. 31-42.

The majority of parasites were obtained from animals slaughtered for food at abattoirs. The author states that "No correlation can be said to have been established between the presence of any of the parasites and marked poverty of condition in the host." He considers that *Ostertagia circumcinta* is the most harmful of the parasites collected by him in North Wales. N.B.

AGRICULTURAL BOOKS, 1925-26.

The following list, prepared by the staff of the National Library of Wales, is a selection of the more important books on Agriculture published during the year Oct., 1925—Sept., 1926. The list supplements *The Hand-List of Books on Agriculture* issued by the National Library, *third edition*, 1926, copies of which can be obtained on application to the Librarian, The National Library of Wales, Aberystwyth.

ADIE, R. H.

Chemistry for agricultural students.
London : W. B. Clive, 1926.
pp. 358. ill. ... ... 5s. 6d.

Chemistry and physics as factors in practical work and observation in agriculture. A textbook for students.

ASCROFT, Robert W.

The conservation of the nation's vegetation; the effect of smoke on plant life.
London : Pr. by Knapp, Drewett & Sons, Ltd., [1925].
pp. 26.

An analysis of the composition of smoke and its injurious effects on vegetation. A plea for the abatement of the smoke nuisance.

BANHAM, George A., *and* YOUNG, William J.

Table of veterinary posology, and other information for the use of students and practitioners.
5th ed. ... ... 8s. 6d.
London : Baillière, Tindall & Cox, 1926.
pp. xii, 360.

BEAN, W[illiam] J[ackson]

Shrubs for amateurs.
London : Country Life, Ltd., 1924.
pp. viii, 118. front., ill. ... ... 5s. 0d.

The selection and cultivation of shrubs, with descriptive and selective lists.

Benjamin, Earl Whitney
Marketing poultry products, *2nd ed.*
New York : Wiley, 1925.
pp. x, 332. ill., bibl. $3.00
Poultry Science Series.

Deals with the production as well as the distribution of poultry products; cc. on qualities, grading and packing of eggs and poultry.

Bourcart, E.
Insecticides, fungicides and weed killers.
. . . by E.B. . . . transl. from the French . . .
2nd English ed. rev. . . . by T. R. Burton.
London : Scott, Greenwood & Son, 1925.
pp. xii, 432. ill. ... ... 15s. 0d.

A practical manual on the diseases of plants and their remedies, for the use of manufacturing chemists, agriculturists, arboriculturists and horticulturists.

Brett, Walter
Carnations and pinks.
London : Newnes, [1926].
pp. 64. front., ill. ... ... 1s. 0d.
How to grow series.

Dahlias and border flowers.
London : Newnes, [1926].
pp. 64. front., ill. ... ... 1s. 0d.
How to grow series.

Pansies, violas and violets.
London : Newnes, [1926].
pp. 64. front., ill. ... ... 1s. 0d.
How to grow series.

Roses.
London : Newnes, [1926].
pp. 64. front., ill. ... ... 1s. 0d.
How to grow series.

Simple flowers from seed.
London : Newnes, [1926].
pp. 64. front., ill. ... ... 1s. 0d.
How to grow series.

Sweet peas.
London : Newnes, [1926].
pp. 64. front., ill. ... ... 1s. 0d.
How to grow series.

BRITISH GOVERNMENT PUBLICATIONS. *Ministry of Agriculture and Fisheries.*

Collected leaflets on insect pests of farm and garden crops.
London : H.M.S.O., 1926.
pp. [ii], 112. ill., pls. ... ... 1s. 3d.
Sectional volume xi.

Guide to the exhibit of the Ministry of Agriculture [at the] Pavilion of H.M. Government, British Empire Exhibition, 1925.
London : H.M.S.O., [1925].
pp. 34. ill., plan. ... ... 3d.

BROWN, E[dward] T[homas]

Your few acres : how to manage them for profitable production.
London : Chapman and Hall, [1925].
pp. xiv, 254. front., ill., pls., diags. ... 10s. 6d.
The management of a farm of one to five acres.

CARLTON, H. W.

Spaniels : their breaking for sport and field trials.
4th rev. ed.
London : Field Press, 1926 ... ... 5s. 0d.

CENTRAL CHAMBER OF AGRICULTURE.

The Agricultural Wages (Regulation) Act, 1924 : ed. . . . with comments by H. Rolfe.
Hereford : Pr. by Adams & Sons, [1925].
pp. 96 [ii] ... ... 5s. 6d.

CENTRAL LANDOWNERS' ASSOCIATION.

The farmer's guide to ownership of land (England and Wales) : hints for the occupying owner, by R. S. Gardiner.
London : The Central Landowners' Assoc., 1926.
pp. 84 ... ... 3s. 0d.
The law affecting the farm-owner, and the rates, taxes and tithe to which he is liable.

CHANDLER, William Henry

Fruit growing.
London : Constable, [1926].
pp. xvi, 778. ill., bibl. ... ... 21s. 0d.
" The purpose of this book is to study the responses of fruit trees or plants, and the responses of fruits as living organisms to their environment."

COLLINS, S. Hoare, *and* REDINGTON, George
Plant products, *2nd ed.*
London : Baillière, Tindall and Cox, 1926.
pp. xiv, 262. ill., bibl. ... ... 10s. 6d.
Industrial Chemistry Series.

An attempt to trace the history of plant products from field to factory, with special reference to the uses and value of fertilisers in promoting increased crops.

COOK, E[rnest] T[homas]
Gardening for beginners : a handbook to the garden. *8th ed. rev.*
London : Country Life, Ltd., 1925.
pp. xxii, 604. col. front., diags. ... 16s. 0d.

CORRANCE, Nora
Rabbit breeding do's and don't's.
London : Methuen, 1925.
pp. [viii], 54. ... ... 2s. 6d.

Concise handbook on the care and breeding of rabbits for commercial purposes.

CORRIE, Frank Ewart
Lime in agriculture. 1, In plant nutrition. 2, In animal nutrition : a handbook for practical farmers, students and others.
London : Chapman and Hall, 1926.
pp. xii, 100. diagrams. ... ... 3s. 6d.

The importance of lime in economic crop production, together with a short account of the functions of lime in animal nutrition.

COX, Joseph F[rank]
Crop production and soil management.
New York : Wiley, 1925.
pp. xxx, 516. front., ill., maps, bibl. ... $2.75

A handbook for students on the methods employed in the northern grain belt states of the United States, emphasising the results of scientific investigations, and analysing existing means of marketing, etc., with practical suggestions for their improvement.

CRAN, Marion, *Mrs.* [George]
Garden talks.
London : Methuen, 1925.
pp. x, [ii], 180. front., ill. ... ... 5s. 0d.

Prepared from gardening talks by the author, broadcasted from the London Broadcasting Station (2LO).

CURTIS, Robert S.

The fundamentals of live stock judging and selection. *3rd ed. rev.*
London : Kimpton, 1925.
pp. 472. front., ill., bibl. ... ... 15s. 0d.

A guide to the characteristic features of various breeds of animals.

DALLIMORE, William

The pruning of trees and shrubs.
London : Dulau, 1926.
pp. 92. front., pls. ... ... 4s. 6d.

Pruning as practised in the Royal Botanic Gardens, Kew, described in simple non-technical language.

DRAIN, Brooks Daniel

Essentials of systematic pomology.
New York : Wiley, 1925.
pp. x, 284. ill., diags., maps, bibl. ... $2.75
Wiley Agricultural Series.

A textbook summarising recent literature, chiefly American, on the subject.

DYKE, W.

Mushroom culture.
London : The Lockwood Press, 1925.
pp. [vi], 88, front., ill. ... ... 1s. 0d.

A handbook dealing with the cultivation of mushrooms in glass houses, frames, sheds and outside.

The science and practice of manuring. *rev. and enl. ed.*
London : The Lockwood Press, [1925].
pp. xviii, 158. ... ... 2s. 0d.

EDWARDES, Tickner

Bee-keeping do's and don't's.
London : Methuen, 1925.
pp. viii, 56 ... ... 2s. 6d.

Concise handbook on the care and breeding of bees.

EMERSON, Paul

Soil characteristics : a field and laboratory guide.
New York : McGraw-Hill Book Co., Inc., 1925.
pp. x, 222. map, diags. $2.50

Soil physics, fertility and microbiology. All the references given are to American publications.

FAIRFORD, Ford

Fruit and the fruit trade.
London : Pitman, 1926.
pp. xii, 154. front., ill. ... ... 6s. 0d.

The nature of the fruit is only briefly described, the chief purpose of the book being a study of the methods of marketing and distribution, and the extent of the fruit trade.

FARADAY SOCIETY, The

Base exchange in soils : a general discussion held by the Faraday Society, December, 1924.
London : Gurney and Jackson, 1925.
pp. vi, 551-617. ... ... 7s. 6d.

Seven technical papers, and a general discussion, on soil physics and chemistry.

FORDHAM, Montague *and* T. R.

The English agricultural labourer : 1300-1925.
London : Lab. Publ. Co., Ltd., 1925.
pp. 64. bibl. ... ... 2s. 6d.

Historical sketch.

GALT, A[lexander] S[eaborne]

The principles and practice of horticulture.
London : Univ. Tutorial Press, Ltd., 1926.
pp. viii, 240. ill. ... ... 3s. 6d.

Summarises the more important principles of fruit and vegetable culture as practised to-day.

GARNER, George

Vegetable growing.
London : Country Life, Ltd., 1925.
pp. 74. front., ill. ... ... 2s. 6d.
Half-Crown Gardening Books.

A popular guide with chapters on exhibiting, storing and diseases.

GRAS, Norman Scott Brien

A history of agriculture in Europe and America.
London : Pitman, [1925].
pp. xxviii, 444. ... ... 15s. 0d.

Describes, for the use of the student and general reader, the more important developments in the history of rural life in Europe and America, and pays special attention to the history of landownership in both countries.

HAWLEY, Ralph Chipman, *and* HAWES, Austin Foster
Forestry in New England. Vol. I. Manual of forestry for the North-Eastern United States.
New York : Wiley and Sons, 1925.
pp. xii, 282. ill. $3.50

HENSLOW, T[homas] Geoffry W[all]
The gardener's calendar : a garden guide for every day of the year.
London : Dean and Son, 1925.
pp. 126. front. (port.). ... ... 2s. 6d.

HEPBURN, John.
Crop production, poisoned food, and public health.
London : Crosby Lockwood & Son, 1925.
pp. xxiv, 182. pls. ... ... 7s. 6d.
Sets out to prove that the present system of farming is detrimental to public health.

HORNER, John Truman
Agricultural marketing.
New York : Wiley, 1925.
pp. viii, 250. ill. $2.50
Wiley Agricultural Series.
The economic principles of marketing and a description of its methods, chiefly as practised in the U.S.A.

IRVING, Walter
Rock gardening.
London : Country Life, Ltd., 1925.
pp. 60. front., ill. ... ... 2s. 6d.
The Half-Crown Gardening Books.
A popular handbook on the construction of a rock garden and its upkeep in summer and winter.

JORGENSON, George Ellington
Veterinary diagnosis and treatment.
New York : Appleton and Co., 1925.
pp. x, 342 ... ... $3.50
"A series of case reports preceded by a brief analysis of the symptomatology and diagnostic procedures."

KEEVIL, John Joyce
Case for world war on Foot and Mouth Disease.
London : Simpkin Marshall, 1926.
pp. 24 ... ... 1s. 0d.
Advocates the immediate slaughter of infected animals and the isolation of areas where the disease exists.

LANDER, George Druce

Veterinary toxicology. . . *2nd ed.*
London : Baillière, Tindall and Cox, 1926.
pp. xiv, 326. ill., bibl. ... ... 12s. 6d.

The origin, properties and effects upon animal organism of poisons, based upon records published in veterinary literature and encountered in practice.

LORETTE, Louis

The Lorette system of pruning, by L.L. . . transl. [from the *4th French ed.*] by W. R. Dykes.
London : Hopkinson & Co., Ltd., 1925.
pp. xliv, 166. ill. ... ... 7s. 6d.

A method of summer pruning of fruit trees.

MACSELF, A. J.

Bulb gardening.
London : Thornton Butterworth, 1925.
pp. 224. col. front., ill., pls., diags. ... 6s. 0d.
The Home Garden Books Ser.

The selection and treatment of bulbs, tubers and corms, including indoor and garden culture.

Plants from seed.
London : Thornton Butterworth, 1926.
pp. 240. col. front., ill., col. pls. ... 6s. 0d.
The Home Garden Books Ser.

Soils and fertilizers.
London : Thornton Butterworth, 1926.
pp. 224. front., ill., pls. ... ... 6s. 0d.
The Home Garden Books Ser.

A non-technical work for the amateur gardener.

MALCOLM, John

Agricultural surveying, including mensuration, road construction, and drainage.
London : Univ. Tutorial Press, 1926.
pp. [viii], 314. ill., diags. ... ... 5s. 6d.

Based on the courses in surveying at the West of Scotland Agricultural College. An elementary textbook on surveying with an agricultural bias.

MILLER, William C[hristopher]

Some parasites of British sheep with some suggestions for their eradication and control.
Glasgow : Young and Co., Ltd., 1925.
pp. 106. front., pls. ... ... 2s. 6d.

Moorhouse, Llewelyn Alexander
The management of the farm.
New York : Appleton, 1925.
pp. xviii, 526. ill., diags., bibl. $3.50
The business side of farming, as influenced by climate, soil, and topography; the organization and operation of farms and agricultural book-keeping.

Morton, J[ohn] W[illiam]
Practical fruit growing.
London : Benn, 1925.
pp. 192. front., ill., pls. ... ... 10s. 6d.
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CONTENTS.

FACTORS AFFECTING THE PRICES OF PIGS IN WALES.

By J. MORGAN JONES, M.A.,
University College, Aberystwyth.

Few matters of agricultural interest have claimed more attention since the war than the question of stabilising the prices of farm produce. Pig prices are proverbially unstable, as is indicated by the wide currency of such statements as "pigs are either copper or gold" and "pigs are never at their value." The complexity of the pig market is such that clear conclusions as to the causes of prices changes cannot easily be obtained. But the study of the influences determining prices will indicate on the one hand the type of action which might contribute to reducing price fluctuation, and on the other, the extent to which the prices of Welsh pigs are governed by local, national or even international forces.

The incidence of these forces will depend partially on the degree in which Welsh pigs are sold in markets which are also supplied by produce from other sources; and also on the extent to which Welsh pigs have to compete with supplies of pig meat brought into the Principality. Though in common with other parts of Britain Wales is subject to foreign competition in this matter, there are considerable differences in the way in which its influences are felt in particular districts. These are due to variations in the system of pig production conducted.

Types of Pig Husbandry.

Although pig-keeping is generally important as a branch of farming in Wales, there are certain rural areas in which pig-keeping is limited by natural conditions. In counties such as Brecon, Radnor and Merioneth and sections of other counties where land is 800 feet above sea level, where mountain sheep-farming is the feature of farming, the pig population is naturally low. The pig trade of these districts resolves itself into the transfer of weaners

and stores from farms which breed to those which require pigs for feeding to meet household requirements of pig meat. These can be termed self-supporting areas in so far as farm requirements are met by local produce; but they do not contribute substantially to meeting the deficiency of other areas. Prices in even these districts are influenced by external factors.

The remainder of Wales forms itself into two fairly well-defined areas in which the production of pigs and pig-meat is surplus to farm requirements. These areas can be differentiated on the basis of the type of demand for which the majority of producers in each attempt to cater. One area, consisting of the parts of South Wales not defined as self-supporting areas, is concerned with producing small pork to meet local demand. The portion of North Wales not dealt with hitherto forms another area, where production is mainly directed to supplying baconers for English markets. Some qualifications of this broad classification will emerge from a more detailed description of each district.

The character of pig production in what is now the small pork area of South Wales has undergone great changes within the last quarter of a century. Prior to this period pigs in South Wales were converted into heavy baconers, but the growth in urban population and the industrialists' demand for fresh lean pork has greatly modified pig production in the area. Farmers are now concerned with the large local demand for pork pigs to be slaughtered at about six score liveweight, and consequently feeding for bacon has shrunk to unimportant dimensions. But all districts of South Wales do not contribute equally or directly to the demand for small pork. Parts of Glamorganshire, and notably the districts of Carmarthen and Pembroke adjoining railway lines, have embarked on liquid milk production, with the result that pig-keeping has been diminished. There are other areas, such as Mid-Cardiganshire and North Pembroke, which are better adapted for breeding than feeding owing to the pastoral and store stock character of the farming. Weaners are despatched from such districts to the feeding districts of their own or adjoining counties, such as South Cardiganshire, South-west Pembroke, and parts of Carmarthen and Glamorgan. In the more densely populated areas pig-feeding on town and garden refuse contributes quite substantially to the total supply of pork. Over the whole of this area by-products of milk, second grade cereals produced on the farm, supplemented by bought barley meal, form the bulk of the diet of the pigs.

It is impossible to estimate the extent to which the South Wales pork demand is met entirely from local produce, but it is

known that pork pigs are normally imported from Ireland and by land from the neighbouring counties of South-west England. South Wales is definitely an importing area as far as bacon is concerned.

What has been described as the bacon area of North Wales contains districts in which pig-keeping varies considerably in importance and character. From the standpoint of the density of pig population, the chief area comprises the cheese districts of Flintshire, South-east Denbigh, and the eastern corner of Montgomeryshire—from Welshpool towards Oswestry. The system of farming here naturally lends itself to intensive pig production since whey forms such a suitable food for fattening pigs, especially for baconers. In fact, pig feeding is necessary to the most profitable utilisation of this by-product of cheese-making. But pig feeding in this area is not confined to producing baconers,[1] and the feeding of porkers and cutters for the winter season is quite prevalent. But the big majority of the pigs are turned into baconers, which are fed to about twelve score liveweight. Baconers are mainly sold in Birmingham and the Midlands, whereas the majority of porkers and cutters are sold in Merseyside and Lancashire towns.

The greater parts of Montgomeryshire and Denbigh are concerned with supplying weaners and strong stores for the cheese districts of North Wales and neighbouring parts of England. These are mixed farming districts where the rearing of young pigs on milk by-products fits in admirably with the general farm economy. Some farmers sell the pigs as weaners at 8-10 weeks old, whereas others keep them up to four or five months, when they are regarded as suitable raw material for the whey feeders.

Still a different type of pig-keeping is seen in the lower lying portions of Caernarvon, notably the Lleyn Peninsula, and Anglesey, where the number of pigs kept is slightly above the average. In these districts pigs that are surplus to farm requirements are mainly turned into heavy baconers for the Midland towns. The features of farming which in the past have largely accounted for the prevalence of bacon production in these areas have been the considerable farm supplies of barley, second grade

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[1] Throughout this paper "baconers" covers a range of pigs which will kill at 160 to 240 lbs. deadweight, with in rare cases some heavier pigs, not counting sows. "Cutters" usually covers pigs which will kill at 120–150 lbs. deadweight, and "porkers" normally covers pigs killing at between 80 and 120 lbs. deadweight. The normal range for porkers in the chief district is more between 90 and 100 lbs. In some districts the distinction between the larger porkers, 110 to 180 lbs., and the cutters, of 120 lbs. upwards, is not very clear.

oats, and potatoes. The correlation between pigs and potatoes in Lleyn has been quite outstanding, and the decline in the arable area of these districts is partially accountable for the diminished pig population which has been noticeable since the war.

As a long period factor which contributes to determining the prices of pigs, as of all classes of livestock, the quality of stock is an important influence. At present the pig population of Wales presents a maze of breeds, crosses and mongrels; but there is every indication that improvement is forthcoming in this matter, and the use of stock, especially boars, of pure breeds is increasing. Already the aim of pig production in the various districts is reflected in the distribution of the breeds. The following analysis of the breeds of boars placed under the Ministry's scheme in 1927 is indicative of general conditions.

TABLE I.

Number and Breeds of Boars placed in 1927.[2]

GROUP.	*Large White.*	*Welsh and Lop Eared.*	*Other Breeds.*	*Total*	*Per Cent.*		
					LW.	*W.*	*OB.*
1. Cardigan, Carmarthen, Glamorgan, Monmouth, and Pembroke........	32	27	12	71	45.	38.	17.
2. Brecon, Radnor, and Merioneth..................	19	9	1	29	65.5	31.	3.5
3. Anglesey, Caernarvon, Denbigh, Flint, and Montgomery,................	49	17	2	68	72	25.	3.
TOTAL	100	53	15	168	59.5	31.5	9.10

The movement towards the reduction of breeds and the standardisation of type is fairly obvious, notably in North Wales. Much of the present apathy towards schemes of livestock improvement is based on genuine ignorance of market requirements as to the best type of pork and bacon pigs. It is to be hoped that joint action between the representatives of producers and consumers will remove much of the present misunderstanding and thus contribute towards a healthier pig industry.

The cyclical character of Pig Prices.

Whatever differences exist between the above named districts in the systems of pig husbandry, they are all subject to the common influences which determine the cyclical character of pig prices. An examination of pig prices in the British Isles for the last half-century or so reveals the fact that prices move in fairly regular swings. About two-and-a-half years of rising prices

[2] Obtained through the courtesy of the Welsh Department, Ministry of Agriculture.

have normally been followed by a period of falling prices of about the same length, with the result that about four-and-a-half to five years elapse between two maxima or two minima, or, in the farmers' terms, between two periods of "gold" or two of "copper". There has been some tendency for the cycle to shorten during the last two decades, and this can largely be accounted for by reason of the more rapid circulation of market intelligence resulting in a quicker adaptation of production to prices.

The almost monotonous regularity of the cycle has on the one hand caused producers practically to acquiesce in its inevitability and on the other has called forth much study on the part of investigators. Examination has been directed to the interrelation of the prices of pigs and pig products, pig population and the cost of pig foods, and several theories have been advanced as to the reasons for the cycle.[3] The existence of the cyclical changes, together with their approximate coincidence in point of time in this country and those from which its imported supplies of pig meat are derived, is well established and this serves to emphasise the international character of the problem. The intimate relationship between maize prices and pig production in the United States is undoubted, and the view has been expressed that British prices are determined by the maize crop. If this is the case, then efforts towards stabilisation on the part of British producers in general would be of no avail.

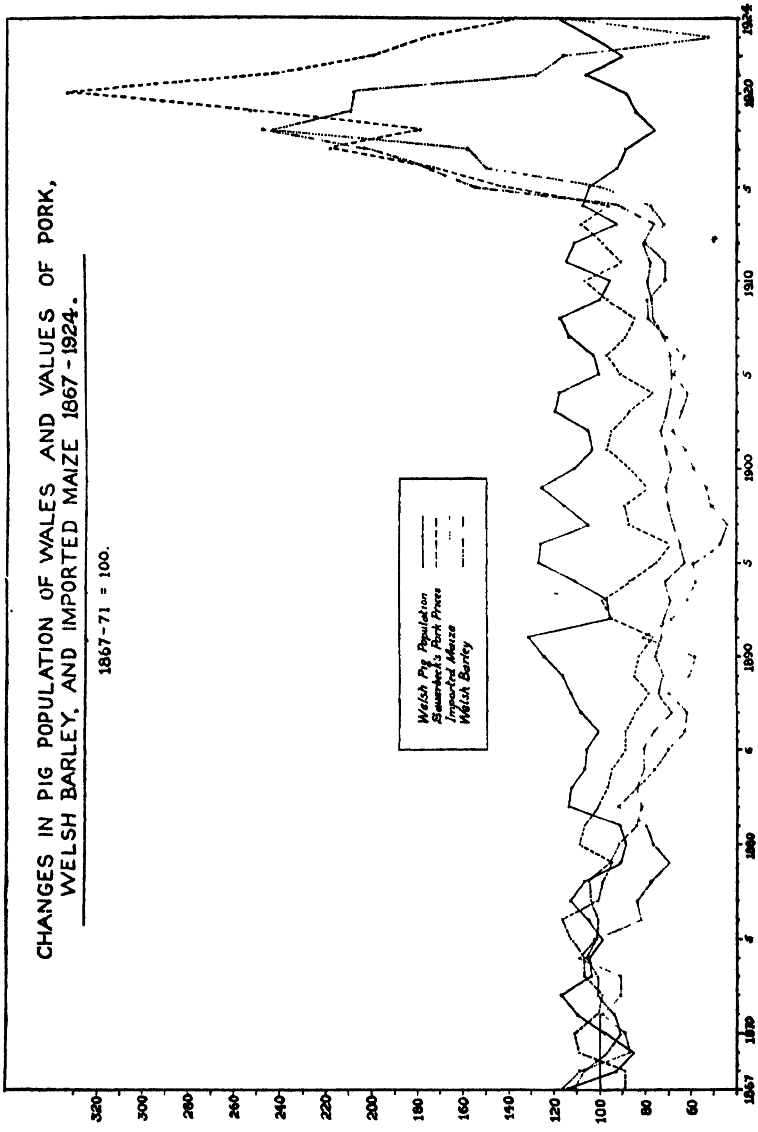
But several considerations lead to doubt of the conclusion that the cycle in home prices is determined directly or solely by the maize crop. In the first place, only about one-fifth of the cereals consumed by pigs in this country is represented by maize. Moreover, the cycle in prices existed in all parts of the United Kingdom when imports of maize and pig meat were a mere fraction of what they are to-day. Whatever influence the American maize crop may have at present is indirect and exercised through changes in the values of other cereals fed to pigs, of imported pig meat, and the effect of these on home prices and production.

It is difficult to determine in general the relationship between the prices of feeding stuffs and the numbers of pigs kept. For the by-products of dairying there are no prices, and for certain arable products or by-products it would be difficult to determine them. Barley meal has been widely fed to pigs in Wales in the past, but the accompanying graph does not indicate any intimate

[3] (1) Marketing of Pigs. Economic Series No. 12, Ministry of Agriculture. (2) Factors affecting the prices of Hogs, Haas and Ezekiel, Washington. (3) The Relation of Production to Prices of Pigs, Ashby and Jones, *Jnl. of the R.A.S.E.*, 1926.

connection between barley prices and pig population. On the other hand the statement that "offals are going up and pig prices will rise" is generally made, but it has little statistical foundation. The feeders' policy will certainly be influenced by

FIG. 1.



the cost of foods, but the breeder will be guided by the prices obtainable for weaners and stores.

A glance at Fig. 1 reveals the clear connection between the prices of pigs and the pig population, low prices being coincident

with a heavy population and *vice versa.* The immediate cause of the pig cycle is to be found in producers' attempts to modify the volume of production according to prices. A period of falling prices is followed by one in which breeding is restricted and sows are slaughtered, and this process in time produces a scarcity of pigs. A period of scarcity causes higher prices and in time producers attempt to take advantage of these by heavier breeding. This process in time defeats its own objects and prices fall to rock bottom again. The demand is steadier than either prices or production, and the attempt at adjustment should be made with reference to the more fundamental and steadier demand rather than to the sharply fluctuating prices.

Failure on the part of farmers to adapt production to demand causes alternate periods of over- and under-production. The short time which the cycle takes to work itself out is due to the prolific yield of pigs and the short period of gestation. These basic physiological facts almost invite the conclusion that some amount of cyclical change in prices is unavoidable unless there were definite information on demand and consumption. The effects of changed breeding policies are cumulative. On an average, six months elapse between two matings, and this period is too short for the results of restriction or expansion in the previous matings to be felt in the markets. While breeding policy is influenced more by immediate prices than by knowledge of the demand, the connection between prices and the breeding of stores will continue to play a large part in making the "cycle".

Concrete evidence of the connection between the prices of pigs and breeding policy is seen in Fig. 2 and the following Table. From the custodians of boars kept under the Live Stock Improvement Scheme of the Ministry of Agriculture, records have been obtained of the number of sows mated each month. In forty-five cases continuous records have been secured for the three years, October, 1924-27, and a large number of incontinuous records have been received. The following Table does not show much difference between the general trend for the larger and the smaller group and results afford an index of the general position despite the fact that only a fraction of the boars in the Principality are represented. For purposes of analysis the returns have been grouped according to the aims of pig keeping in each area. Group I represents the South Wales pork district, Group II the self-supporting counties, whereas Group III consists of returns from the North Wales bacon area.

TABLE II.

Changes in Services per Boar on Welsh Farms October, 1924—September, 1927.

Continuous Records for 3 Years.	No. of Boars.	1924–5 Total Services.	1924–5 Average per Boar.	1925–6 Total Services.	1925–6 Average per Boar.	1926–7 Total Services.	1926–7 Average per Boar.	Percentage Changes. 1924–5=100. 1925–6 %	Percentage Changes. 1924–5=100. 1926–7 %
Group 1	21	1609	76.6	1812	86.2	2101	100	112.5	130.6
Group 2	10	587	58.7	645	64.5	764	76.4	109.9	130.
Group 3	14	1032	73.7	1330	95	1275	91.	128.9	123.5
Total ..	45	3228	71.7	3787	85.	4140	92.	118.5	128.3
Non-Continuous Records.									
Wales 1	69	4890	71	—	—	—	—	—	—
Wales 2	76	—	—	6286	82.7	—	—	116.5	—
Wales 3	112	—	—	—	—	9516	85	—	120.

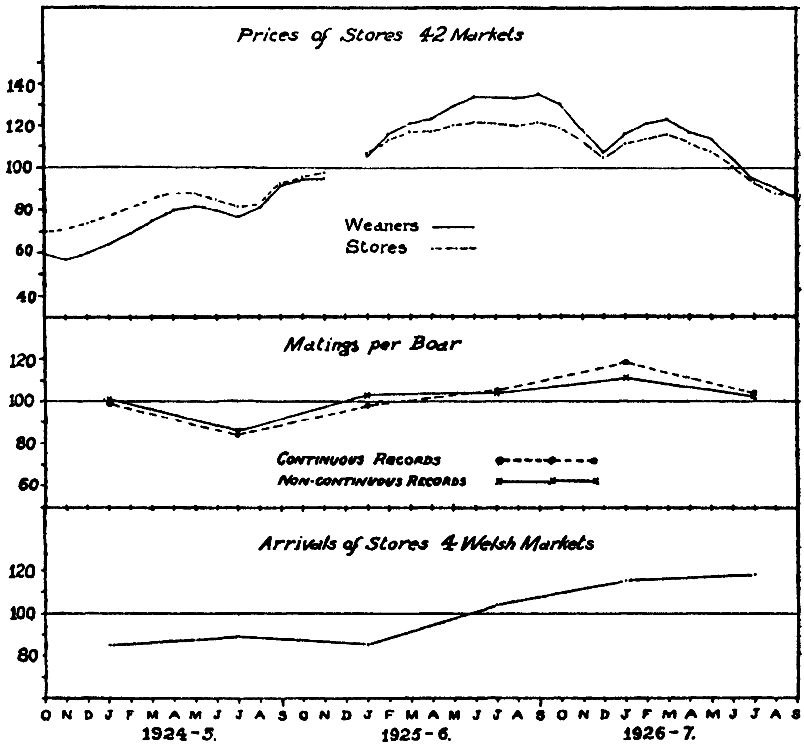
This Table shows that in all districts the matings per boar have been greater in the past two years than in the year October, 1924-25. There are minor differences between districts in the pace at which the increase has taken place, but the general results agree very closely and clearly indicate a changed breeding policy on the part of pig keepers. When this is viewed in conjunction with Fig. 2 it can be concluded that action on these lines occurs in all pig cycles and is the immediate reason for their occurrence.

After a period of low and falling prices in 1924, a recovery set in about the beginning of 1925, and prices advanced uniformly until September and October, 1926. After suffering a set-back for two months, prices recovered until March, 1927, and since then have fallen consistently. Changes in the volume of mating during this period follow the price curve very closely. In Fig. 2 changes in mating and supplies of stores in four markets have been shown for six monthly periods so that the influence of the seasonal changes which occur within every cycle might be diminished. It is natural that the adjustment of breeding to prices is not perfect either in degree or in point of time. For instance, the rising prices of Autumn, 1924, did not produce heavier mating immediately, because previous experience of a long period of falling prices had shattered farmers' confidence in the market. But by the end of 1925 prices had risen sufficiently to induce heavier breeding, which was maintained progressively for twelve or fifteen months. By 1927 this over-shooting of the mark had resulted in markets being flooded with pigs and the rapid decline in prices was inevitable. Despite the obstacle to

obtaining a perfect correlation between matings and supplies in markets, the general trend of the curve showing changes in supplies is in keeping with the other factors. There is, of course, a time lag of at least six months before changes in breeding policy will affect the markets, and this largely accounts for the cumulative effect of changes in breeding on supplies, and consequently, prices.

FIG. 2.

Deviation from mean monthly prices, matings, and arrivals of stores, 1924–27.



The intimate connection between breeding policy and prices offers the chief explanation of the immediate causes for the cycle in pig prices. Moreover, it is clear that producers in all districts, irrespective of the intensity of pig production, contribute equally to the results. The adaptation of production to demand is more immediate and less costly at present than in the nineteenth century, but it can be rendered more effective and less wasteful by the wider circulation of better market intelligence as to requirements, prices and forthcoming supplies.

Seasonal changes in Prices.

Apart from the cyclical fluctuations in pig production and prices from year to year there are influences at work which produce seasonal changes in prices within each year. The effect of these is difficult to describe owing to the continuous swing in the pendulum of prices from year to year. But two types of demand can be traced as affecting the prices of pigs over short periods. Changes in the consumption demand will affect the prices of fat pigs directly and immediately. The effect of these changes on the prices of weaners and stores will be indirect and subject to some time lag. The type of direct demand from feeders which affects store prices can be called a farm demand. The former will be conditioned by such factors as variations in the purchasing power of the public and seasonal changes in their diet, whereas the latter will be determined by such influences as variations in the farm supply of pig foods and the time of the year at which the finished product is to be marketed. Changes in supplies of bacon and pork from external sources will also affect the demand for home products.

Prices of Fat Pigs.

Pig feeding in this country is designed for the production of meat to be consumed either as fresh pork or as cured bacon and hams. It has been estimated that at least 50 per cent. of the pig meat produced in the United Kingdom is consumed as fresh pork.[4] This, however, may be an overestimate. It does not follow that all the pig-meat which goes to the butchers and pork-butchers for sale as pork is thus sold and consumed. Some is cured by one method or another and is sold to compete with the bacon from the pigs primarily intended for bacon. In view of the continual alternation between pork and bacon production on the part of the majority of producers, the prices of each over long periods move in harmony. The margin may be upset by temporary conditions, but it is likely that this close relationship between pork and bacon pigs will be maintained for some years at least in this country. The prohibition of the import of fresh pork from the Continent since July, 1926, has placed a premium on pork production and since then the margin which previously existed between the prices of porkers and baconers has been about doubled. It is difficult at this stage to indicate the ultimate effects of the embargo on pig prices or to forecast the final results in this country of its continuation. It is, however, quite clear that the embargo will not maintain steady

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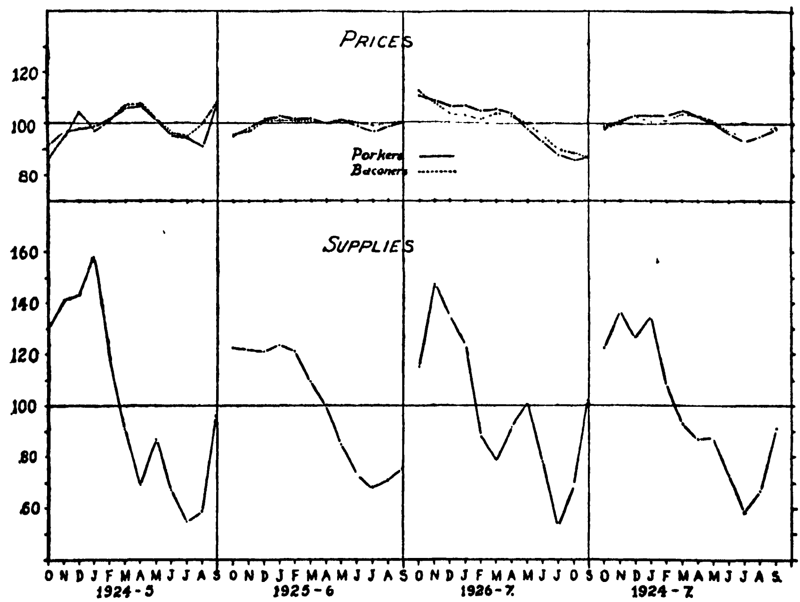
[4] Guild: Production of Meat in U.K. *Jnl. of R. Stat. Soc., July,* 1920.

prices, or indeed change to any extent the tendency towards cyclical fluctuations. The retention of the embargo provides the home producer with a greater demand in the fresh pork market, but this will not cause the prices of porkers and bacon pigs to move independently of each other. With the consumption of fresh pork remaining at its present dimensions, the pork market will not absorb the whole produce of British pig husbandry. A certain proportion will remain to be converted into bacon, which has to compete with foreign supplies. If the fresh pork market absorbed the whole of the pig meat of the country then it is arguable that bacon and pork prices would move independently. But without a permanent reduction in the country's pig population or an increase in fresh pork consumption, production will, as at present, be alternated between pork and bacon, as dictated by the price barometer.

FIG. 3.

Seasonal changes in prices and supplies of fat pigs. Monthly deviations from mean for each year, 1924–27.



Seasonal changes in the demand for pig meat are determined largely by consumers' habits. This is so in the case of both pork and bacon, although the latter is a cured product capable of storage for some time. But the degree to which the possibility of storing bacon contributes to the stabilisation of the price of bacon pigs has been very greatly modified by changes in the public taste for bacon. The type of bacon now in demand is that

which has been very mildly cured and a good deal of bacon is now consumed between about six weeks and two months subsequent to slaughter. Consequently although it is now physically possible to cure bacon in fairly even quantities throughout the year, there is a clear tendency to cure more in winter than during the summer months. It is impossible to measure changes in the monthly consumption of bacon, but it is certain that less is eaten during May to July in each year. The prices of bacon pigs tend to be below the average from June to September and to be well above the average from December to March. This country is a heavy importer of bacon, but fluctuations in imports are not responsible for the seasonal changes in the price of bacon pigs, since shipments from abroad arrive in fairly uniform quantities month by month.

The seasonal changes in the prices of fat pigs are shown fairly clearly in Fig. 3. In this and the following graph the monthly mean has been worked out separately for each year. The continual operation of the cyclical movement largely disguises the seasonal fluctuation, but these emerge very clearly when three years are taken together. The demand for pork is more seasonal than that for bacon and as a rule pork prices tend to sag more during the summer months. The proverbial disinclination to eat pork during May to August is substantiated by some statistical evidence and is reflected in prices. Pork prices are generally below the average during this period, and tend to be high during December to March. The following Table shows

TABLE III.

Percentage changes in Average Monthly Prices of Fat Pigs, and Numbers Slaughtered in four Welsh Abattoirs.

	Three years, October, 1924–27.		*Numbers slaughtered, 1925.*	
	Baconers.	*Porkers.*	*2 S. Wales.*	*2 N. Wales.*
	Per cent. of Average Price.		*Per cent. of Average Killings.*	
January	100·7	102·8	118·4	93
February	101·4	103·2	117·2	106·4
March	103·8	104·7	102·1	116·1
April	103·1	103·3	95·7	109·6
May	100·8	100	88·3	98·5
June	97·2	96	59·4	84·3
July	94·8	93·3	68·7	78·7
August	96·5	94·9	83·2	85·7
September	98·6	98	113·6	111·9
October	98·3	99	105·5	94·4
November	100	101·3	101·8	112·4
December	103·1	102·5	145·9	118·4
Monthly mean	100	100	100	100

fluctuations in the prices of fat pigs in relation to statistics showing the seasonal character of public demand for pig meat.

The above Table clearly indicates fluctuations in the demand for home killed pork. There is a general concensus of opinion to the effect that consumers are tending to even out their consumption of pork over the whole year. In South Wales pork is being regarded to an increasing extent as a normal part of the industrialists' diet, though it would seem that prolonged industrial depression will definitely restrict the demand.

Prices of Weaners and Stores.

The above mentioned effects of seasonal variations in the diet of the public on changes in the prices of pork and bacon pigs play a part in determining farm demand. June to August in each year is definitely a period during which feeders are not anxious to put supplies on the market. This factor influences the time at which stores are bought and sows are mated. Normally baconers are sold when 8-11 months old, cutters at about six-and-a-half to seven-and-a-half months and porkers between four and five months. Consequently a pork producer who aims at supplying the Christmas market will purchase weaners[5] in September, or if a breeder also, will take the farrowings of July. A bacon producer, on the other hand, wishing to sell baconers at the same period will try to arrange matings for November and onwards of the previous year or buy strong stores about May of the same year. This is the type of adaptation which good management based on observation of seasonal changes tries to secure. But as shown by Fig. 4 there are farrowings all through the year and all the pigs except those for breeding find their way to one consuming market or the other.

The seasonality of the farm demand is also governed by changes in the farm supply of pig foods. In all parts of Wales milk by-products are basic foods in the breeding and feeding of pigs. Consequently, the strength of feeders' demand is partially determined by the available supplies of whey, skim- and butter-milk. The milk supply begins to increase in April, expands rapidly in May and generally reaches its maximum in June. Although the flow is heavy for the next two months, supplies contract continually until the end of September, after which they tend to equality to the end of the year. In so far as ample supplies of pig food on the farm determine the strength of the demand for weaners and stores, it should be expected that prices

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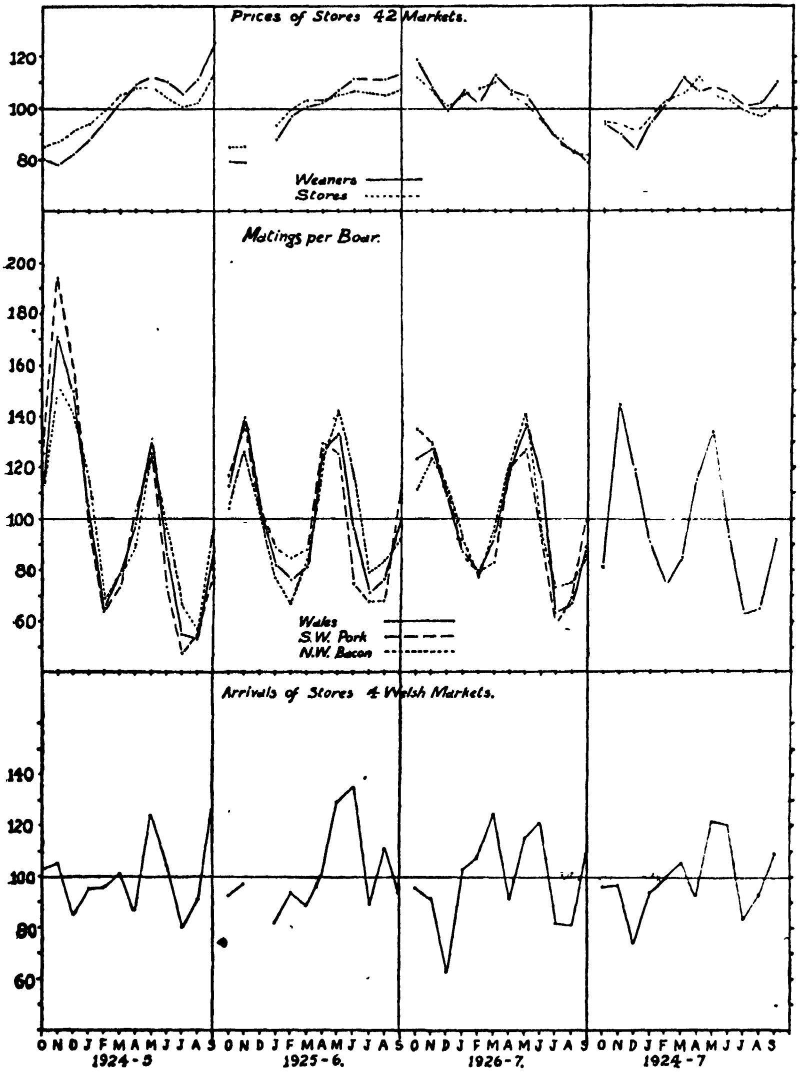
[5] Weaners are pigs 8–12 weeks old and stores 12–16 weeks. For definition of fat pigs see note p. 7.

FIG. 4.

Seasonal changes in prices, matings, and arrivals of stores. Monthly deviations from mean for each year, 1924–27.



would normally be high in May and June. In the more arable districts, where home-grown cereals are fed to pigs, the farm demand tends to be maintained in the autumn, when the year's corn is being threshed. In some districts also the feeding of potatoes and roots is fairly extensive, with the result that the demand for pigs for winter feeding is strengthened. This remark would apply more to the demand for strong stores in the self-

supporting areas than to either the pork or bacon areas where potatoes and roots are not fed to any great extent.

On the demand side two factors, the attempts to arrange production to meet changes in the volume of consumers' demand and to adjust the periods of rearing and feeding to variations in the farm food supply, determine the seasonal prices of weaners and stores. It is likely that of the two the latter is the more important, since its influences are immediately felt by the producer. Fig. 4 illustrates the effect of these factors on the monthly prices of pigs. Prices touch the maximum in March and April and remain well above the average until the end of June, while the lowest point is reached between October and December. The keen demand during the spring and early summer is caused by heavy purchases of pigs to be fed on the large forthcoming supplies of milk by-products. Prices are further inflated, especially in bacon-producing areas, by reason of this being the period at which feeding must be begun if the fat pigs are to realise the best prices. On the other hand, the prices of weaners tend to harden in August and September in sympathy with a keen demand for pork three or four months later. Moreover, prices tend to be low in November and December because milk is scarce and pigs bought for feeding at this period, especially in bacon areas, would not come out at a favourable time. In this connection a statement of what many farmers in the cheese area of North Wales regard as an ideal arrangement will be helpful. It is a common practice to feed the spring litters for bacon and to convert the late summer pigs into porkers or cutters, because the latter, if fed to bacon, would come on the market when prices are apt to be low.

Conscious efforts are made by breeders to adjust production to meet the seasonal changes in demand for weaners and stores. In so far as the returns of matings received from custodians of boars placed under the Ministry's scheme are representative of general conditions, it is evident that the timing of farrowings is definitely achieved. Fig. 4 shows clearly that more sows are mated in November than in any other month and the main reason for this is to be seen in the high prices obtainable for weaners and stores in the early spring. A time lag of about six months must be allowed for between matings and the time at which the progeny begins to affect the markets. In districts where stores are kept up to four months old before being bought by the feeder, the time lag is about eight months. The progeny of sows mated in November will arrive in the markets at a time when prices are very favourable. The natural consequence of a concentration

of mating in November is that May shows another peak, though this is less marked. Heavy breeding in May is less a matter of choice than one of necessity to the producer, since the prices of weaners and stores are less favourable in October than in the spring. The relative disadvantage to the breeder is diminished by the possibility of his converting the autumn litters into pork for the winter season. It is a custom in some districts for farmers to sell the spring litters as weaners or stores and convert the autumn litters into pork on their own account.

The influence of the seasonal distribution of mating on supplies of pigs arriving in markets is clear in Fig. 4 and is also indicated in the following Table :—

TABLE IV.

Percentage Variation in Sows Mated, and Pigs Marketed in four Welsh Towns. October, 1924–27.

	Monthly matings.	*Monthly Supplies.*	
		Fat Pigs.	*Store Pigs.*
October ...	81·6	122·7	96·7
November ...	144·5	137·3	97·1
December ...	119·4	126·8	74·7
January ...	90·5	135·4	94·0
February ...	74·1	109·3	99·8
March ...	84·8	93·6	105·9
April ...	115·3	87·6	92·9
May ...	133·8	88·3	121·7
June ...	93·2	72·9	120·2
July ...	63·4	59·0	83·9
August ...	65·8	66·7	93·5
September ...	92·2	91·9	109·3
Monthly mean	100	100	100

The large supplies of stores (pigs up to sixteen weeks) forthcoming in the spring and early summer can be traced back to the heavy matings in October to December. The large number of fat pigs marketed in winter can be partially attributed to the concentration of mating in May, although autumn matings would also augment this supply. The scarcity of reliable statistical data upsets the swing of the supply curve at one or two points, but the general results are in keeping with expectations.

Conclusion.

It is evident that the factors affecting the prices of Welsh pigs are numerous and complex, and that prices are determined to a large extent by conditions over which the Welsh producers have no control. But this should not be an excuse for a fatalistic attitude on the part of farmers, since some degree of stabilisation is possible by local action. Better information on the trend of market requirements, prices, and the collection of

information on forthcoming supplies would discount the alternate periods of optimism or pessimism which are the immediate cause of the cycle. The systematic collection and analysis of service records over a wide area forms an essential basis for the forecasting of future prices. It can be fairly confidently stated on the basis of the returns supplied by boar keepers in October, 1927, that prices will not recover very much before the end of summer, 1928. The extension of information of this sort would contribute to making the process of adapting production to prices more effective and less wasteful.

The seasonal changes in breeding and preparation of stores within the year will remain; they are the result of adaptations to farm conditions, and also to some extent to feeders' requirements arising from consumers' demands. The seasonal changes in production and prices of pork and bacon within the year will also remain for this production again is partly an adaptation to farm conditions and also to consumers' demands, although the spread of cold storage facilities may tend to more even consumption of pork and the greater control possible in bacon-curing to the more even demand from the curers. The sharp changes from year to year—or two-year period to two-year period—over the "cycle" are not necessary. They are certainly not due to any such fundamental conditions on farms as supply and price of feeding stuffs, nor as far as can be ascertained to equally sharp changes in the total of consumers' demand or in the total demand of either the pork or bacon markets. More information on demand and consumption is required, for it is to this rather than to immediate prices that the adjustment of production should be made. In an importing country like Great Britain the alternative supplies are important, yet these supplies are not alone responsible for the cycle in home production and prices. If producers could get a clearer idea of the fundamental demand, and keep this in view, it would be a much better guide to production policies than the immediate prices which are themselves nearly always the result of maladjustments of supply to demand or of production to consumption requirements.

Perhaps the most immediate need of the industry in Wales is more definite information on market demand for pork and bacon pigs as regards quantity, type and quality. The continual changing of breeds and crosses, notably in South Wales, is an indication of the weakness of the marketing structure in this respect. Improvements in production, as regards breeding and method of feeding, are both necessary and must proceed hand in hand with the evolution of a better marketing machanism.

PRICES OF DAIRY COWS AND DAIRY PRODUCE.

By R. Harding Wynne, N.D.A.,
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Dairying in Wales.

Farming in Wales is fundamentally a live-stock industry. A considerable proportion of the land is unfitted by altitude and poorness of quality for arable cultivation, and stock-raising has become the back-bone of the farming policy of these areas. Much of the highland is given over to sheep farming, but nevertheless Wales has the greatest percentage of store cattle in Great Britain and the increase in cattle population during the last fifty years is most marked in the Principality in the case of this class of stock. Cattle are reared, not only for home use, but to supply a considerable export trade to the English fattening areas. Welsh stores do particularly well and are highly valued in the Leicestershire feeding districts. Some fattening is carried on within Wales itself, but this side of the industry is of comparatively little importance and is tending to decrease.

Liquid milk production in Wales is of small extent, being limited, more or less definitely, to certain areas in the South. These are to be found in Glamorganshire, Carmarthenshire and Pembrokeshire and depend upon the neighbouring industrial districts for their market. In the North there is an increasing tendency for Flintshire farmers to supply milk in liquid form to Liverpool, Birkenhead and Manchester, and numerous farms in the vicinity of the Wrexham industrial district are concerned with the supply of milk to that area. But every town and large village in the Principality has its local area of supply for liquid milk.

Little cheese is produced outside those districts of Flintshire and Montgomeryshire that border upon the cheese-making area of Cheshire. Apart from these, and one or two small areas in the South, the only cheese produced in Wales comes from scattered individual farms or from certain of the small co-operative and similar cheese factories that are still in operation in North Wales. In the processes of assembling and balancing supplies for the fluid milk trade in South Wales some surplus is made into cheese, but it has been produced mainly for immediate sale.

The rest of the country is given up practically entirely to a combination of stock-raising and butter-making, a combination

that varies from farms such as exist in Brecon and Radnor, and where butter is definitely a bye-product of stock-raising, to a position of almost equal importance of butter and yearling and other stores on farms where the calves are weaned earlier in the year. The importance of the dairy herd in Wales has, therefore, a somewhat different foundation from that found in the English dairying districts. It is bound up intrinsically with the store cattle industry and comparatively little specialised dairying exists. It must also be recognised that on many of the lower hill farms the dairy herd serves as a stabilising influence in seasonal labour demand. On such farms, where the need for labour on the land or with the sheep flock is concentrated into one or two periods of the year, little reduction in labour costs would follow the abolition of the herd of dairy cows. Bearing in mind these facts, it is not surprising that, in spite of the lack of any considerable specialised dairying area, the 1925 figures show that of the total cattle in the Principality 42.15 % were dairy stock, a figure but 3.76 % below the English equivalent. The farms of Wales contain about 10.8 % of the total cultivated area of England and Wales combined, and they carry 12.7 % of the total cows, and 13 % of the total of all cattle.

For the majority of stock farmers in Wales the production and sale of liquid milk in any quantity is at present far from being a feasible project. Distance from the consuming areas and transport difficulties in the many isolated parts of the country will form a considerable obstacle at any time. In addition, the fulfilment of a milk contract has been rendered virtually impossible by supply irregularities arising from the practise of concentrating upon spring calving for stock raising purposes and the opinions that prevail against methods of calf-rearing without fairly large quantities of milk in one form or another.

The Welsh farmer has then of necessity to fall back upon some other means of utilising his surplus milk, and the problem arises as to whether cheese or butter production should accompany the store stock industry. This does not hinge entirely upon a question of price. In many cases the Welsh farmer has not the technical knowledge required for cheesemaking nor does the quantity of surplus milk justify the capital outlay necessary for the essential plant. Whey, too, he does not consider a suitable substitute for skim-milk for calf rearing. Butter-making, on the other hand, needs little capital outlay, can be efficiently carried out by members of his family, provides suitable bye-products for his stock and has the additional advantage that it finds a ready local market. It is common, then, to find stock-raising and

butter-making proceeding hand-in-hand in Wales, and the greater part of the country is devoted to this type of farming. An interesting indication of the importance of butter-making is given by the fact that the butter sales on 152 lowland farms, of average rental 14/8 per acre, represent 45.1 % of the rent and rates; and the butter sales on 181 highland farms, average rental 8/3 per acre, represent 38.1 % of the rent and rates.

Summarising the position: There are districts in North and South Wales specialising in milk production; and milk farms round all towns. The farmers of these milking areas and milk farms purchase most of their cows—probably on the average 75 % of the total; and in many cases the whole herd. Those of the cheese district in the north-east also purchase the great majority of their cows. In other areas of North Wales where a good deal of cheese has been made, and where occasionally milk is sold, rearing goes on alongside milk or cheese production. In the butter and store stock areas, covering the greater part of the country, the purposes served by the herd are variable in importance. Where cows of the Hereford type or Hereford cross are kept calves are frequently reared on cows and form the chief product of the herd, although some butter is nearly always made and cheese is sometimes produced for farm use and local sale. The importance of pigs varies with that of butter or cheese. Somewhat similar conditions are found in certain areas where the Welsh Black cattle are kept except that rearing calves on cows and seasonal cheesemaking are perhaps less common. Where the Shorthorn type of cattle prevail suckling calves on cows at pasture is uncommon and butter takes a place of high relative importance. Over large areas the products and bye-products of the dairy herd are prime draft cows, store cattle, butter and pigs—as stores, pork or bacon according to district.[1] Draft cows, fat for the butcher; dry for the feeders; or down calving or fresh for milk producers, are products of different systems of herd maintenance and management under varying conditions. In some proportion they appear in all districts, but only those for the milk trade are treated in this study. In some cases the calves produced are sold at two years and upwards as beef, either from the farm on which bred or others in the same locality; but the typical product is store stock. The steers go for feeding purposes, but the heifers may find their way to feeding pastures or stalls or to other dairy herds as the markets determine. The bulk of the Hereford and Welsh Black types

[1] See article by J. Morgan Jones in this *Journal*.

and crosses of heifers sold off the farms go for feeding, but many of the Shorthorn type go to milking districts in Wales or England.

The whole of the types of dairy herds in Wales have interconnections. A good or bad market for liquid milk or cheese affects the demand for heifers and prime draft cows. The demand for store pigs in the cheese districts affects production and prices of weaners and stores in the butter district. Prices of butter and pigs (in several forms), as well as those of store cattle, help to determine the result of the typical dairy herd over a great part of Wales.[2] This study is an effort to display some of the movements of prices and their causes in these interrelations.

Price Movements.

In an attempt to indicate the connection between the prices of dairy produce and those of dairy cattle it becomes essential to consider the price movements from three aspects. These are: the long period trend extending over a number of years; seasonal movements of a definite character that occur within the year; and temporary modifications of these movements. These three types of movements are the results of the action of many different factors and their combination at any one period serves to determine the price at that period. Each of these types must then be considered separately and the factors influencing them enumerated and discussed.

In connection with butter and cheese prices the effects of the import trade must not be forgotten. Fluctuations due to such influences are discussed as they arise in later sections. The following table will give some idea of the present importance of the imports of dairy produce into England and Wales.

Home Produced and Imported Dairy Produce, 1921.[3]
(Expressed as millions of gallons of milk).

	Home produced.	*Imported.*	*Total.*	*Percentage imports to total.*
Butter ...	394	1,084	1,478	73·3
Cheese ...	100	309	409	75·6
Condensed and Dried Milk ...	35	77	112	68·8

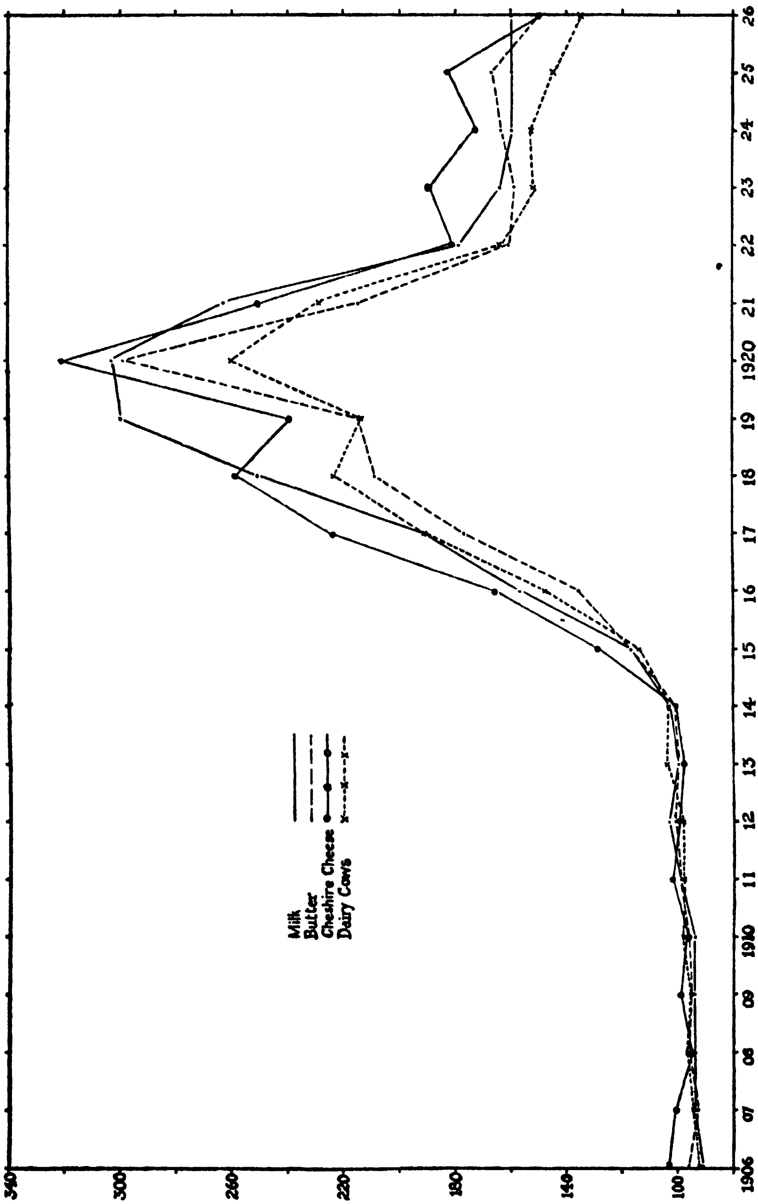
2 See article by J. Morgan Jones in this *Journal*.

3 Departmental Committee on Distribution and Prices of Agricultural Produce. Interim Report on Milk and Milk Products, page 12.

The Long Period Trend. Fig. I demonstrates the relative movements of yearly average prices of milk, butter, cheese and dairy cattle from 1906 to 1926. The graph is drawn from index

FIG. 1.

Changes in Prices of Dairy Cows and Produce, 1906–1926.



figures calculated upon the average prices from 1911 to 1918. The close relationship of the four curves is at once apparent. It must be borne in mind, however, that the general price level

determined by general financial and economic conditions plays a large part in the determination of prices over a long period such as this. Particularly is this fact important in a period of abnormal conditions such as has occurred since 1914. Fluctuations in prices during this period are to be attributed in much greater part to the peculiar economic conditions existing than to any simple application of the law of supply and demand to the products dealt with. The general price level rose gradually about eight points from 1906 to 1914. Then came the war and a rapid rise to a peak in 1920 approximating to 301 points. An even more rapid fall occurred during the slump of 1921 and 1922, and 1923 finds general prices only 55 % above the pre-war level. A slight recovery took place in 1924, but a further fall to 1926 brought the general price level down to 151.

The dairy cattle and produce figures follow closely upon these lines, but there are one or two deviations that are worthy of note. In 1919 cheese prices fell, and butter prices were checked in their rise, by war-time control; and an immediate reflection of this is seen in the fall of dairy cattle prices that occurred during the same year. Milk prices in 1919 continued to rise rapidly and were speedily approaching their peak. This, no doubt, checked a more serious decline in cow prices, but such a position in normal times should not be of such a nature as to depress cow prices in any noticeable manner. The year 1919, however, was one of abnormally small dairy produce imports and it is evident that, during that year at least, butter and cheese were sufficiently large items in the British farmer's programme for the effect of price changes in these commodities on those of cows to be considerable.

The movement of cheese prices during the earlier and later years of the period require some explanation. There appears to be some indication of a two year cycle in the price movement of this commodity that might be attributed to some periodic action of a definite and powerful controlling factor. This movement appears on closer examination, however, to be largely due to the more or less accidental coincidence of a number of minor influences superimposed upon the influence of the general price level.

Thus a low pig population in Cheshire is coincident with a high cheese price in 1909 and the high cheese price of 1911 occurs in conjunction with a considerable decrease in Dutch cheese imports. The fall in price that occurred in 1908 was of such a scale as to be almost entirely discounted by the concurrent drop in general price level and a general connection between cheese

prices and the general price level is observable right through the pre-war period. On the demand side, such influences as industrial wage rates in Lancashire and Yorkshire, unemployment and industrial disputes, doubtless make themselves felt from time to time.[4]

The similarity of movement of the four curves generally throughout the period is a significant feature and it is at once apparent that dairy cow prices, although they did not rise to the heights reached by dairy produce during and immediately after the war, are greatly dependent upon these prices and reflect their changes with comparative rapidity.

The Seasonal Movement of Prices. A marked seasonal movement is common to the prices of milk and milk products in this country and it may be attributed mainly to the influence of the factors of supply and demand. The comparative perishability of the produce and the lack of cold storage facilities make an almost immediate sale essential, and under such conditions any tendency towards over or under production is reflected more or less instantaneously in the price. Thus the seasonal price movement presupposes a similar movement in production rising to its peak when prices are low and reaching its lowest level, more or less coincident with the peak of the price curve.

Fig. II gives the monthly price fluctuations of milk, butter and cheese and dairy cows for three years and clearly shows the existence of a similar seasonal movement in each case. Roughly, this consists of a fall for the first six months of the year and a corresponding rise from July to December. This is a reflection of what occurs in production. The combined effects of spring calving and the growth of grass result in an increase in milk production from January to June, when a decrease commences under the influence of autumn conditions and the nearing close of the natural lactation period. Though this may serve as a general indication of the position it is obvious that the factors influencing the various products differ considerably and the relation of price to production in each case must be considered separately.

Cheddar cheese has not been inserted because it is of no importance in Wales, but perhaps it should be noted that movements of prices of this variety are somewhat different from those of Cheshire. The milk prices used are examples of contract prices in areas of North-east and South-west Wales. The movements shown are variations from the mean in each case.

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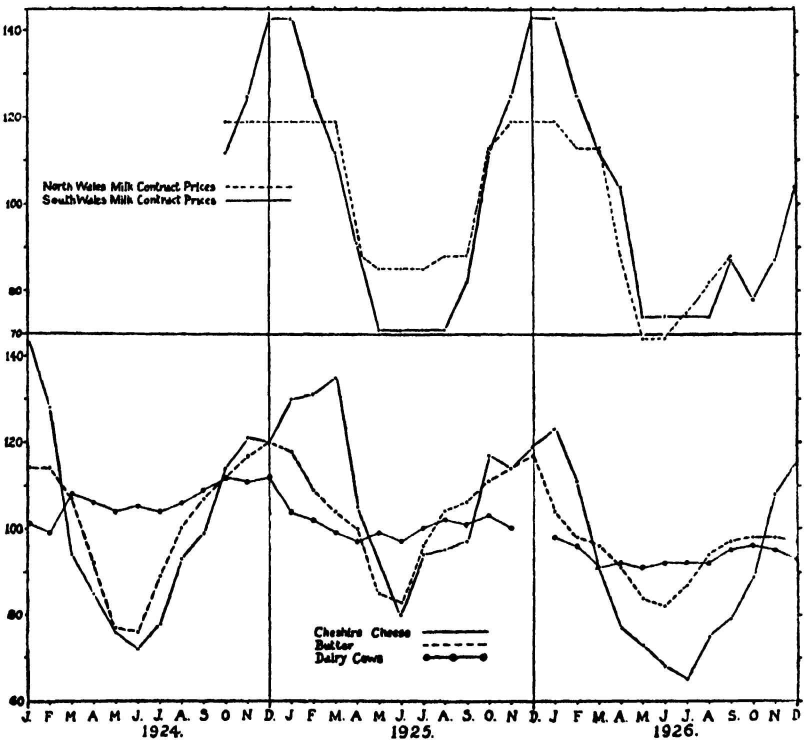
[4] Cheshire cheese only is dealt with, for Cheddar is of little importance in Wales.

Butter. The fact that butter production in Great Britain depends mainly upon the utilisation of milk not specially produced for the purpose tends to accentuate seasonal fluctuation in production and price. This is particularly evident in Wales, where butter-making is bound up with the store stock industry over large areas. For rearing purposes spring calves have been preferred and calving arranged accordingly, or rather, the natural course of the breeding has been allowed to remain with but little modification. This system creates a spring and early summer

FIG. 2.

Seasonal Trend of Prices of Cows and Produce.



milk flush which increases with the growth of grass, and more and more of which becomes available for butter-making as the calves are weaned. Consequently butter production increases from January until July and butter prices decline during approximately the same period. From July until the close of the year production decreases with the milk yield. Cows are tending to dry off and the growth of grass is gradually becoming less. There is therefore a rise in butter prices during this period. The custom of " potting " butter, prevalent in Wales during

July and August, has the effect of relieving the pressure on the market during those months and prevents a further decline in prices, but its subsequent release in autumn and winter, if only for consumption on the farm, must have some effect upon demand at that time. The lowest point of butter prices, during any one year, is seen to occur in June. This is a month earlier than the peak of production and its earlier appearance is due to the influence of butter imports. The heaviest import figures are found in April and May, some two months previous to the peak of home production. Similarly the fact that the lowest butter imports occur in October has the effect of fixing the price peak in November or early December, whereas it would occur somewhat later if the market were dependent solely upon home supplies.

Denmark, New Zealand and Australia are the principal sources of imported butter and any abnormal price change in all or one of these is sufficient to have an effect upon home prices. In October 1924 Danish butter was exceptionally dear owing to the active buying of Danish supplies by Germany. This Danish shortage combined with the general seasonal butter shortage to produce higher November and December prices than might otherwise have been expected.

Cheese. The price fluctuations in the Cheshire cheese market during any one year are very similar in many respects to those of butter. The factors influencing them, however, are somewhat different.

Cheese production is a more specialised branch of the dairy industry in this country than is butter-making, and the question of variation in supplies from surplus or bye-product milk does not arise in the same way. The common practise is, however, still one that causes marked seasonal production movement. Cheese-making on most farms concerned is confined mainly to the summer season, approximating to a period from April to October, and farmers endeavour to arrange the calving season so that most of the milk is produced during that period. During the summer months the cows are out on grass and feeding and labour costs are greatly reduced. In addition this system produces but little winter milk, and the small supplies usually have been disposed of with comparative ease. There is another type of farm where winter milk is considerable and is disposed of in liquid form, cheese being made only in summer, but this type is tending to decrease in numbers as there is always the fear that difficulty may be met in finding a market for milk for a short period only. The poor cheese prices of the post-war period have

also had their influence in driving this type of farmer entirely into liquid milk production. But the ripening period for cheese and the greater possibilities of storage than in the case of butter may and sometimes do cause slight variations in the relations between immediate production and price. Most Cheshire cheese, however, is of the quick ripening type.

Usually the new season's cheese begins to make its appearance on the market in considerable quantities in March and April, and prices decline from this point until milk production slackens in June or July. A rise in price now occurs and extends beyond the cheese-making season until an increase in supply causes another fall and commences another cycle of fluctuation. Other things being equal, it might be supposed that the peak of cheese prices would occur immediately prior to the commencement of the season's operations. This does not conform to fact as other influences make themselves felt at this point.

While there appears to be no noticeable regularity in the quantities of foreign and colonial cheese imported and consequently no regularity in the fluctuation of price there exist obvious effects of importation upon the price fluctuations of home produced cheese. Supplies from the two main sources, New Zealand and Canada, do not overlap to any considerable extent but work together to create a fairly even supply over the whole year. The heaviest imports from New Zealand occur in the first half of the year while Canadian cheese is received in greater quantity from July to December. Nevertheless, any exceptional deviation from these periods makes itself felt upon home cheese prices. In the spring of 1925 New Zealand shipments were comparatively small, and the increase in Canadian cheese imports over the 1924 figures was not sufficient to make up the deficit. Consequently, cheese prices remained high fairly late in the year and the decline was not felt until April when the new season's home-produced cheese began to reach the market. At the close of the same year an exceptionally early large shipment of cheese arrived from New Zealand in December and coincided with even greater imports from Canada. This had the effect of bringing the annual spring decline in price earlier and it commenced in January, 1926. Heavy Canadian imports coupled with an overlap of New Zealand supplies were responsible for the break in the autumnal price rise that occurred in August and September 1925.

The practise of withholding late August and September cheese, in the hope of obtaining the advantage of a rising market is rather apt to create a scarcity in September and October with a consequent rapid rise in price. Any comparatively sudden

release of this cheese, whether by farmer or factor, may result in a depression of prices. To this cause, augmented by heavy imports in the October of each year, may be attributed the declines in price that took place in December 1924 and November 1925.

Milk. The position with regard to milk production and prices differs fundamentally from that of either of the two main manufactured dairy products. The need for daily or even more frequent deliveries of fresh milk and the high rate of perishability of the product combined with the comparatively stable week-to-week demand render a regular daily production the ultimate goal of milk-selling dairy farmers. Those farmers concerned with the retailing of milk are forced, by virtue of the necessity of maintaining a regular supply to their customers, to adopt what means they can to increase winter production and to bring their winter and summer supplies as much into line as possible. Except in the districts where holiday and health resorts are found, and in which there is a floating summer population, the size of a retail milk round is dependent chiefly upon the quantity of milk produced in winter, and any surplus that may occur during the flush months has to be disposed of by butter-making or by other means less profitable than the liquid trade. The general summer demand may be a little greater than that of the winter, but during certain parts of the summer individual retailers may find a greater or smaller demand according to the class of family or district which they serve.

A similar position exists in the wholesale market, to which the majority of liquid milk producers look for the disposal of their product. The system of contracting has been made necessary by the regularity of demand and the natural irregularity of supply over the year. Theoretically, the farmer contracts to supply an even quantity of milk throughout winter and summer, or to limit summer supplies to a certain proportion of increase on those of the winter, but the natural factors operating make it a practical impossibility to discount the summer milk flush. Much may be done in the direction of levelling supplies by the adoption of a system whereby calvings are spread over the autumn and winter and not concentrated entirely in the spring, but this makes heavy the costs of winter milk production particularly as regards the feeding items. These two facts, the existence of surplus milk in summer and the high costs of winter milk production, form the basis of the present milk contract systems.

Table I shows contract prices offered for milk in two Welsh areas from 1924-1928. These two examples will serve to illustrate

some of the possible variations in wholesale milk agreements. It will be seen from an examination of these figures, together with the relation of one to the other illustrated in Fig. 2, that, while under both agreements the prices move in accordance with costs of production and seasonal flush, the difference between summer and winter prices is very much greater in one case than in the other.

TABLE I.

Prices under two Wholesale Milk Contracts, 1924–1928.

North-East Wales.

	1924–25 per gallon.	*1925–26 per gallon.*	*1926–27* No general agreement reached.	*1927–28 per gallon.*
	d.	d.		d.
Oct.	19	18		14
Nov.	19	19		17
Dec.	19	19		18
Jan.	19	19		18
Feb.	19	18		17
Mar.	19	18		15
Apl.	14	14		13
May	13½	11		10
June	13½	11		10
July	13½	12		11
Aug.	14	13		12
Sept.	14	14		12
South-West Wales.				
	d.	d.	d.	d.
Oct.	13	13	9	10
Nov.	14½	14½	10	11
Dec.	15½	15½	12	14
Jan.	15½	15½	12	13
Feb.	14½	14½	10	11
Mar.	13	13	9	9
Apl.	10½	12	8	8½
May	8¼	8½	7	7
June	8¼	8½	7	7
July	8¼	8½	8	8
Aug.	8¼	8½	8	8
Sept.	9½	10	8	8½

The south-western contract prices are for milk mainly for manufacturing purposes and, as such, are of necessity lower than those ruling in the purely liquid market. In addition they constitute a monthly flat rate for all milk delivered. While this makes it possible to offer a comparatively high price for winter milk, it also results in a low summer price as the purchaser must be compensated for the conversion of the surplus that is to be expected during this period. As all milk delivered is paid for at

the flat rate, it follows that all milk delivered must share the burden of the surplus. The absence of irregularities in the curve from month to month (Fig. 2) is indicative of the certainty with which milk prices can be forecast by the expert milk trader. Only one break occurs—the price in September 1925 had evidently been fixed at slightly too high a level and was in need of revision, but it must be remembered that this figure was fixed by a contract price determined, a year in advance, in September of 1924.

The north-eastern contract is of quite different type. The prices are higher throughout and less fluctuation occurs. This can be attributed to the facts that the milk is primarily destined for the liquid trade and that payment is made upon a comparatively fixed quantity of milk, surplus being paid for at a lower rate. Even in such a contract, however, summer flush cannot be entirely relegated to surplus prices and some allowance must be made for it in the agreement. Thus during May, June and July, 1924 the full price of 1/1½ per gallon was paid for all milk not exceeding 15 % over the daily average delivered between November 1st and February 28th, 1925. Between 15 % and 30 % excess was paid for at 1/1 per gallon, 30 %—60 % excess at 1/0½ per gallon, and over 60 % excess at 1/- per gallon. Under such an agreement the producer is not penalised at all providing his summer supply does not exceed 115% of the winter quantities. During the following year the unpenalised excess was increased to 20 % and April included in the period of application of the surplus clause, but this year surplus prices (above 120%) remained unspecified. The basic period, too, was altered, being calculated on supplies from October 1st, 1925, to January 31st, 1926. No agreement was arrived at, in this particular case, for the season 1926-27, but it is interesting to note that the agreement in force during 1927-28 more closely resembles the south-western example. No basic period is fixed and all supplies exceeding 12½ % of the quantity contracted for are reckoned as surplus. Prices are more variable than in former years, and surplus prices are fixed throughout the year at the contract price less 1d. per gallon for the first 25 % surplus and 2d. per gallon over 25 %.

Although the factors influencing the returns from liquid milk production are in reality similar to those affecting the prices of butter and cheese they take on a somewhat different apparent significance. The essential difference exists in the fact that while the butter or cheese maker is free to discontinue production during the period when milk production costs are at their highest, the liquid milk demand must be met continuously from day to day. This stresses the effect of production costs upon liquid milk

prices and their direct influence becomes more apparent than a more simple application of the relation of supply and demand. The value of the surplus and eventually its price is determined by the prices of products, and in Wales practically entirely by butter and cheese prices, though it is not here so formally related to cheese prices as in the case of the London agreement between the N.F.U. and the Milk Traders, where it is fixed at 2d. per gallon less than the price of imported cheese per lb.

The Influence of Abnormal Climatic Conditions.

Butter and cheese prices are considerably affected from time to time by temporary abnormalities in the climatic conditions. Cold or warm weather in spring will cause corresponding lateness or earliness in growth of grass, and the duration of warm weather into the autumn has the effect of prolonging or curtailing the seasonal milk production in a similar way. A summer drought may cause a grass shortage that is reflected in a consequent rise in dairy produce prices.

Several instances of this type of movement are apparent between 1924 and 1926. A few weeks of cold weather experienced in April 1925 checked grass growth and a reflection of the consequent drop in milk production is seen in the steadying of butter prices at that time. In the same year a July and August drought was experienced and its influence was one of the factors causing the sharp rise in butter and cheese prices during those months. The early break in the cheese price rise has been explained in a previous section.

The effect of these temporary changes in weather conditions is, of course, equally applicable to milk production for the liquid market. The ultimate reaction is, however, not to be found in milk prices but in dairy cow prices. Further reference to this fact will be made later.

The Relation between Dairy Cow, Milk and Milk Product Prices.

Prices of dairy cows, relative to those of milk, butter and cheese are comparatively stable, but there nevertheless exists in their movement a well defined seasonal fluctuation. This is closely connected with fluctuation in milk production and through that with the prices of milk and milk products. Other factors make their influence felt from time to time, but broadly it may be said that as milk production increases there is a fall in dairy cow prices; and, with a reduction in the supply of milk, cow prices tend to rise.

TABLE II.

Production of Milk and Dairy Produce (England and Wales), 1925.[5]

	Milk. Millions of gallons.	%
Liquid Milk ...	888	79·5
Butter ...	166·5	14·9
Cheese ...	56	5·0
Cream ...	6·5	·6
Total ...	1,117	100·0

An indication of the possible degree of influence on cow prices of the different aspects of the dairy industry is given by the relative production table above. The most potent factor is seen to be the liquid milk market. As the milk used for making butter and cheese represents only one-fifth of the total it would appear that prices could have only a minor influence upon cow prices. This, however, is not necessarily the case. Under some conditions, and in certain seasons, the selling pressure of producers who are in danger of having to sell or use milk for manufacturing, yet having facilities for reaching the fluid milk market, may have a considerable influence on the price of milk for immediate consumption and therefore on prices of dairy stock. Moreover, useful as are such general figures, local conditions have to be considered. In districts where the normal practice is to make cheese the prices of cheese will be the dominant local factor. This is the position on the north-eastern border of Wales. Satisfactory prices for milk or cheese will exercise their influence on the dairy stock market by creating a strong demand, and *vice-versa*. Good prices for butter, on the other hand, may tend to keep cows off the market; or low prices tend to increase the supply of dairy stock. Much depends on the relative importance which individual farmers attach to selling cows or making and selling butter. But in considering the position both local and general circumstances have to be borne in mind. While there is a more or less general market for dairy stock, with considerable shifting of stock from one district to another, the movements of stock and in stock prices are not so rapid or so great as those in prices of products.

Seasonal movement in Dairy Cow prices. Over a number of years the seasonal fluctuation of dairy cow prices may be described as consisting of the following parts :—

[5] Report on Agricultural Output of England and Wales, 1925, page 65.

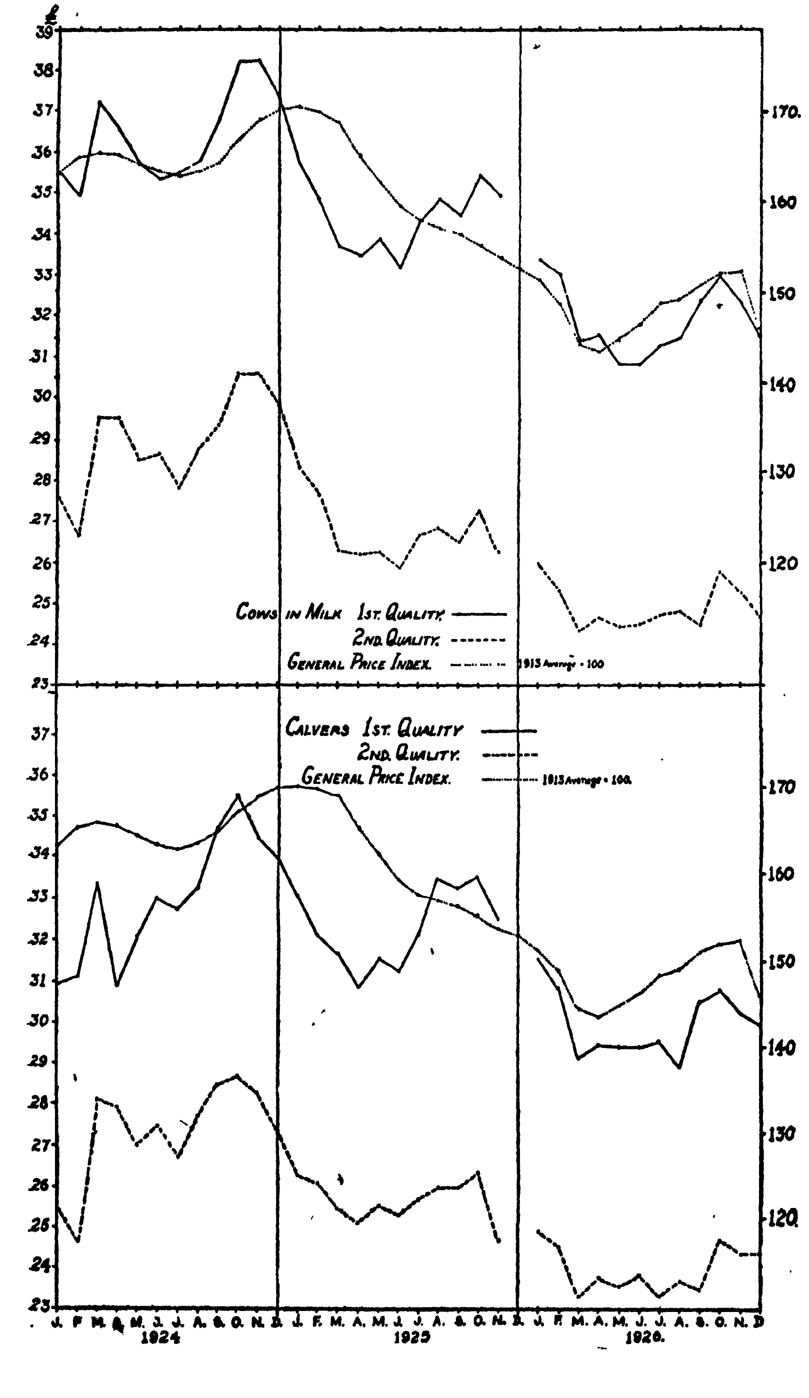
1. A decline from January to June of a comparatively gradual nature. This corresponds to the period when increasing numbers of cows are coming into milk and when the milk flow is further augmented by the spring growth of grass.
2. A somewhat sharper rise from June to October as the combined influences of a decreasing milk flow and a decreasing grass growth come into play. In addition immediately prior to the peak in October considerable demand is created by the necessity that confronts liquid milk producers of securing their winter milk supply. The fact that milk contracts are arranged at this time of the year increases the natural activity. Many farmers, in an endeavour to maintain supplies, or to contract for larger quantities than previously, are apt to make heavy purchases of dairy cows in September and October.
3. This demand being satisfied, the number of cows changing hands decreases rapidly and there is a gradual fall in price until the close of the year.

   Or, taking what may be called the market-year for milk and cows; a steady decline from October to the following June, and a rise from June to October; and a repetition of these general tendencies each year.

This is the general position, but a closer examination of the movement during the three years 1924-26 shows that it is liable to considerable variation from time to time. It is convenient for this purpose to classify dairy cows into cows in milk and calvers each of first and second quality. There are one or two features of this classification that are worthy of note. Over the whole period the movements of the individual classes are very similar, although certain irregularities (some examples of which will be described later) occur. In neither quality do the prices of calvers rise to the level of those for cows in milk, there being a very regular difference in price of about £1 10s. 0d. for first quality cows and £1 for those of second quality. This difference may be taken as some indication of the factor of calving risk that enters into the question of purchase of calvers. The possible value of the calf must be taken into consideration, as also must the need for an immediate increase in the milk supply. The fact that the prospective purchaser is better able to judge of the milk-producing qualities of a cow at the beginning of the lactation period than during the period immediately preceding calving will tend to give an additional value to the former class.

FIG. 3.

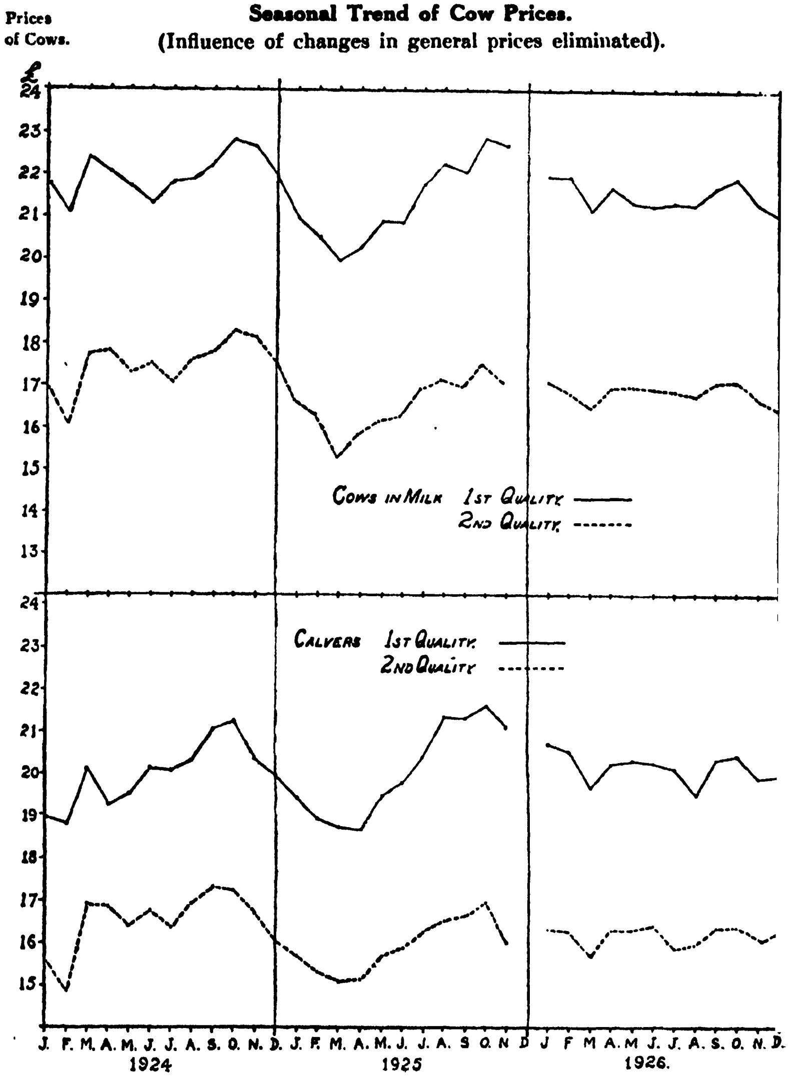
Monthly Prices of Dairy Cows.



The seasonal movements in all classes are well demonstrated during the years under consideration. The autumn peak is particularly clearly marked in 1924 and 1926, while the January to June decline can be best traced in 1925. Another feature of the

FIG. 4.

Seasonal Trend of Cow Prices.
(Influence of changes in general prices eliminated).



seasonal movement that is not at first perhaps so obvious is illustrated by the drop in the price of calvers occurring in July and August 1926. This is even more marked in the figures for

1922 and is also traceable in 1924. It is probably an indication of the extent of prejudice against " August calvers " that exists in the dairy farming industry.

Fig. 3 shows the prices of dairy stock 1924-26 and necessarily indicates the great influence of the general level of prices. Except for a few months in 1924, and again at the end of 1926, general prices were falling rapidly during the period. As previously indicated, the whole group of dairy products are sensitive to changes in the general level of prices, and dairy stock follow the prices of products in some measure in seasonal changes, and completely in long term trends. The Figure shows the general connections between the prices of dairy stock and the general level of prices; but it also shows the *seasonal* changes in prices of dairy stock occurring in spite of the changes in general prices.

The influence of the trend of general prices can be eliminated and the seasonal movement of prices of dairy stock shown more clearly; and this has been done in Fig. 4. This Figure shows the seasonal changes in prices of dairy stock with the influence of the trend of general prices eliminated. In this elimination the actual monthly figures for the general price level have not been used, but have been substituted by a three months' moving average, on the assumption that dairy stock prices in any particular month would be more subject to the influence of general prices over the quarter than to the level in that one month. Apart from variations noted in the text the seasonal variations are fairly clear. They were most clearly displayed in 1924-25. In 1926 the rise to October was small, especially in the case of calvers. This was doubtless due to the lower prices of milk expected, and realised, in the new contracts for milk made in that and the previous month. These prices, however, appear to have been underestimated and fixed slightly below the level warranted by the actual conditions of the market.

In the spring of 1924 distinct deviation from the regular movement is seen extending to each of the four classes of cattle. The usual decline is interrupted by a sharp rise from February to March representing about £2 10s. for first quality cattle and £3 10s. for second quality. This may be attributed to the creation of an abnormal demand by the restocking activities of farmers whose herds had been sadly depleted by the extensive epidemic of foot and mouth disease of the previous autumn and winter. The effects of this demand are particularly noticeable in the case of second quality cattle where, not only is the rise one of approximately £1 higher than for the first quality, but the

high level is maintained for a further month into the spring. In this year the usual decline occurring during the first six months is practically discounted by this exceptional movement.

An example of another deviation arising from an entirely different cause occurs during 1925. A period of drought in July and early August resulted in the premature stoppage of the milk flush. The reaction of the liquid milk industry to such a position as this differs somewhat from that of butter or cheesemaking. The natural result in the case of the latter aspects of dairy farming would be an increase in the price of the product to the consumer, this increase being subject to such influences as might be brought to bear upon it by the condition of the import trade at that time. The comparative stability of milk prices under the contract system and the reluctance of consumers to accept changes in retail prices except at the customary periods of spring and autumn, however, renders almost impossible such temporary price changes in the liquid milk market. Supplies must be kept up and a demand for dairy cows is created. When the relative quantities of milk produced for the liquid and manufactured markets are considered it is to be expected that such demand will have considerable effect upon cow prices. To such conditions may be attributed the rise in dairy cow prices that occurred in August, 1925. It is to be noted that calver prices rose during this month in direct opposition to their usual tendency. The demand in August was of a purely temporary nature and prices fell again by September. The normal peak occurred as usual in October, thus creating an apparent double peak in that year.

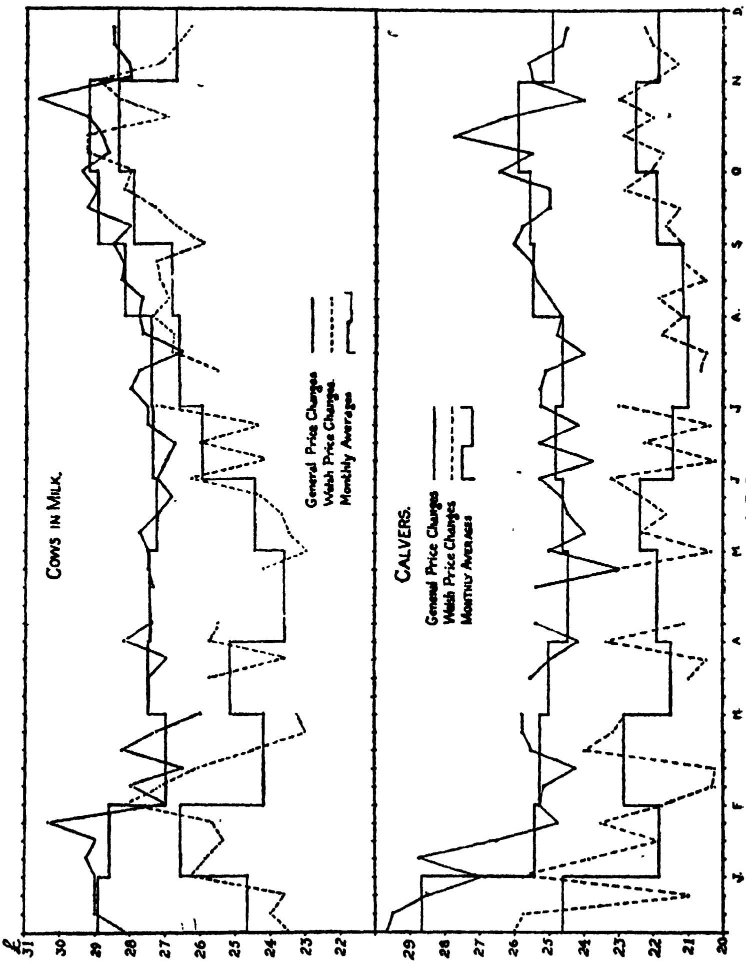
Similarly, although the general tendency is for dairy cow prices to decline during the first six months of the year, this tendency is subject to considerable variation. A late grass season or a cold spell limiting the growth of grass for some weeks may be the cause of a slight rise in cow prices breaking into the general decline. On the other hand, when a particularly favourable season is experienced, little evidence of recovery in cow prices may be expected before June.

Dairy Cow prices in Wales.

The fewness of specialised dairying farms in Wales and the part that the dairy herd plays in connection with the store stock industry both tend to produce a type of animal that is poorer in quality, from a purely dairying point of view, than the average English dairy cow. When the aim is production of store cattle,

and the steers must necessarily go to feeders, while there is no special market for maiden heifers as stores, there is naturally a tendency amongst producers to keep more or less to a beef type. There are certain districts in which good dairy stores are available, and where many are sold; but it has to be remembered that when the best cows are drafted from the herds continual effort

FIG. 5.
Weekly Prices of Cows.



is required to keep up the milking quality of the remaining stock. Add to this the necessity for an animal that is hardy and adaptable to the poorer conditions existent in the Principality and it will be seen that Welsh prices for dairy cows cannot be as high

as those indicative of the average in England and Wales.[6] In 1926 the Welsh prices for cows in milk averaged but little above those for "second quality" stock, while the average calver price in Wales failed to reach even this figure. Truly representative figures for cow prices in Wales are exceedingly difficult to obtain owing to the fact that very few purely Welsh markets are reported and to the great proportion of transactions that are conducted privately in districts remote from marketing centres. The fact that the border markets of Chester, Oswestry and Shrewsbury were included in those from which the Welsh figures were obtained does not give the prices quite the low value they might otherwise attain.

Fig. 5 shows the weekly and monthly variations in prices of dairy stock during 1926 in England and Wales (general) and in Wales only. Breaks in the weekly figures occur where the number of quotations is too small to give representative prices.

The comparatively low quality of the stock deters much attempt by farmers from the English specialised dairying districts to seek new strength in this direction, except it be under the spur of unusual circumstances such as followed the foot and mouth disease outbreak of 1923. Relatively little outside competition exists and this not only tends to lower the average price but is a partial explanation of the excessive week-to-week fluctuations of dairy cow prices in Wales. Other reasons for this instability of price are to be found in the nature of the country and in the prevalence of stock-raising in the agricultural systems practised. The isolation of the Welsh markets and the difficulty of obtaining reliable market intelligence often leads to a wide price difference in the various markets for the same class of stock for the same week. The difficulty of access to the markets of many of the more remote districts renders supply exceedingly irregular and is the cause of considerable trade being carried on privately. To a large extent trade on the higher farms is localised and any cows that change hands are more apt to do so from farmer to farmer, direct or with the possible intervention of a dealer, rather than by means of the distant auction mart.

Despite this considerable week-to-week variation, however, Welsh cow prices exhibit much the same seasonal movement as

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[6] Estimates of the average milk yield in different divisions of England and Wales may be seen in the *Report on Agricultural Output of England and Wales*, 1925, page 64. These yields do not include whole milk fed to calves and thus naturally show unfavourable results for stock raising areas; but comparatively low yields are indicated for Wales even if the figures for the Welsh divisions are not taken exactly at their face values.

is generally true of England and Wales. There is a similar spring and early summer decline, a similar rise to an autumn peak and a similar fall to the close of the year. There is, however, apt to be less autumn demand in a country to such an extent devoted to spring and summer milk production than where a liquid market has to be supplied all the year round. The fact that the chief external dairying district likely to influence cow prices in Wales consists of the cheese-producing area of Cheshire, where production is also concentrated into the summer season, increases rather than decreases this tendency. The result is seen in the 1926 prices, where, although a good recovery occurred in the prices for cows in milk in Wales from June to November, no rise in Welsh calver prices can be noticed before the third week in September.

General Conclusion.

The importance of the dairy industry in Wales is dependent upon its close relationship to stock-raising rather than to the specialised production of milk and milk products. In the greater part of the country butter-making is the most general method of disposal of milk that is in excess of rearing requirements.

In England and Wales generally there is a marked seasonal fluctuation in the production of milk and milk products, although considerable effort is made to level production for the liquid milk market. This results in a similar seasonal movement in prices which, despite the influence of the import trade, in all the cases mentioned is well defined.

A close connection between the production and prices of dairy produce and the prices of dairy cows is apparent both in the long period trend and in seasonal movement, the seasonal fluctuation being directly attributable to the relationship of supply and demand in the dairy produce markets. Generally the most powerful factor influencing dairy cow prices, apart from, or rather in conjunction with, the biologic and climatic reasons for variation in production, is the supply to the liquid milk market. This is not felt so keenly, however, in Wales and cow prices in the Principality are dependent to a greater extent upon rearing practice and summer milk production. Nevertheless a seasonal movement does exist in cow prices in Wales that is similar to that indicative of cow prices generally; but Welsh prices are, as a rule, considerably lower than the average.

POTATO AND ROOT CROPS ON WELSH FARMS.

ANALYSIS OF COST, 1926.

By Thomas Lewis, M.Sc.,
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Root crops enter the farm cropping system for two distinct purposes :—

1. As cleaning crops;
2. As providers of succulent foods essential for successful winter feeding of livestock.

Under Welsh conditions, where the greater proportion of tillable land is subject to alternating periods of 3—4 years' tillage and short grass leys, the importance of such crops for cleaning purposes would be comparatively small compared with land which would be permanently under tillage. Yet the close connection between the acreage of swedes and turnips and the total tillage area shows that these crops have taken their place in the rotation as cleaning crops. The acreage has declined with that of the tilled land, while the numbers of livestock for which winter feed is required have been increasing. In the case of mangolds, however, there is evidence that the importance of the feeding value of the crop is regarded as of more importance than the soil improvements resulting from cultivation. If the potato crop is included with the root crops, as it is thought of with those crops, the position is somewhat different. As will be seen later in tables showing the labour expended on crops, the potatoes are sometimes planted on relatively clean land, and in any case are not treated as a cleaning crop to the same extent as the swedes. The latter crop takes its place in the rotation specially for this purpose.

Arable Area and Cleaning Crops.

The total arable acreage of Wales declined between the years 1884 and 1914 from 923,823 to 691,787 or 23.2%. Between 1914 and 1918, partly as a result of rapidly rising prices during the war, and the compulsory breaking up of grassland during the food shortage period, the arable acreage for the Principality rose rapidly to a point slightly higher than 1885, the previous peak year, and reached a total of 934,961 acres. From 1918 the fall in arable acreage has been nearly as rapid as the phenomenal war-time rise, and has continued unchecked up to 1926, when it reached the lowest point for the whole period under review. The actual decline for the eight post-war years was 26%.

Variations in the acreage of different root crops show different relationships to the total tillage area. Turnips and swedes show a fall in acreage which gives a high degree of direct correlation with the total tillage area. The actual decline was 25.2% compared with a fall of 26% in the total tillage area.

Up to 1918 war-time conditions seem to have exerted but little influence on the acreage devoted to these crops. The years 1918 and 1919, however, show a sharp rise in acreage, probably resulting from the necessity during these years to use a larger proportion of the swede crop for human consumption, and the high prices of purchased feeding stuffs.

The decline in the potato area has not followed the decline of the tillage area quite as closely as swedes and turnips, the actual fall being 18% for the whole period. During the period 1914-1918 there was a rise of 11.7% followed by a fall of 14.0% from 1918 to 1926.

Swedes, turnips and potatoes have, however, in the main, followed fairly closely the decline in total arable acreage. Mangolds, on the other hand, show a different tendency and apart from annual fluctuations in acreage there has been an actual increase in the area devoted to them during the whole period. The trend shows a distinct upward tendency. The actual increase in acreage under mangolds during the whole period was 4.5%. This, however, does not show the exact position. In the five years 1884-1888 they occupied 0.79% of the arable land, while in 1909-13 they occupied 1.55% and 1922-26, 3.03%.

A comparison of changes in the total tillage acreage and the farm root crop acreages of England and Wales for the same period shows similar movements in both countries. Swedes and turnips are grown to a smaller extent than formerly, but the decline in the acreage has been more rapid in England. Mangolds in both countries have shown slight increase in acreage. Opposite movements have occurred in the case of potatoes and the English acreage has gradually increased in contrast to the fairly rapid decrease in Wales.

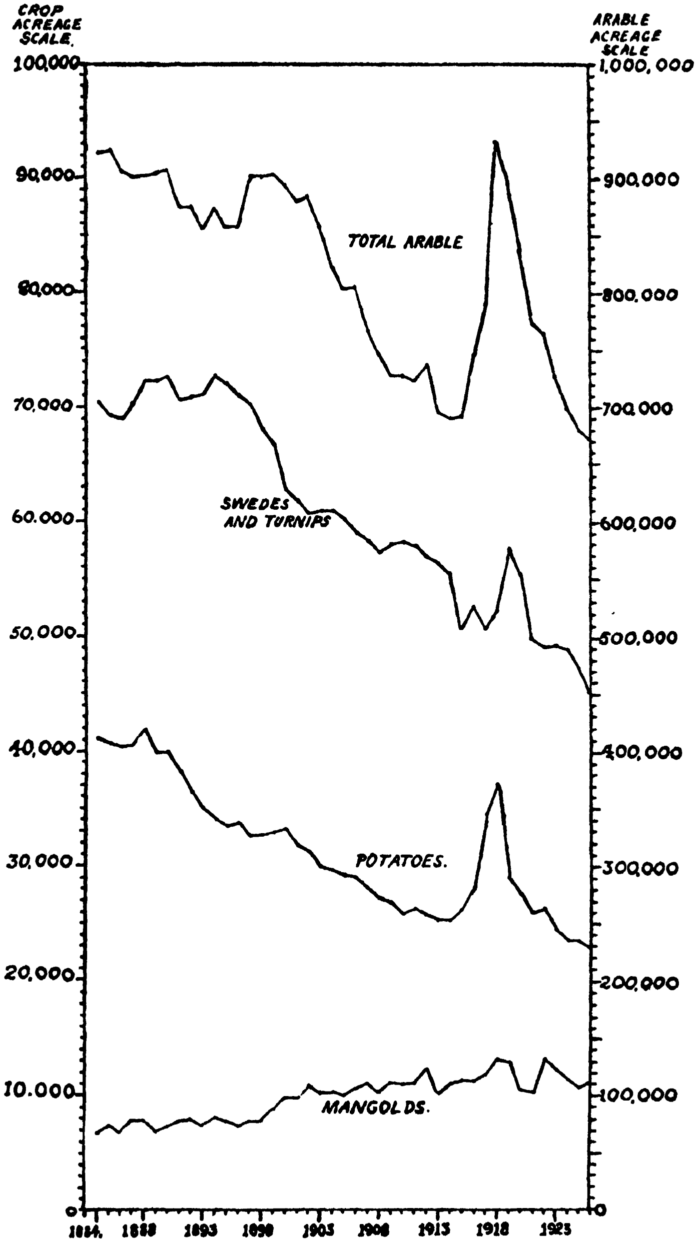
Fig. 1 illustrates the relative changes in acreage of the total arable land and the most important root crops and potatoes from 1884 to 1926.

Production and Requirements.

All these three crops have been influenced proportionately by the increase in production costs during the last fifty years, hence there must have been factors other than costs affecting the area devoted to them.

FIG. 1.

Total Arable Acreage, and Acreages under Root Crops for Wales, 1884–1926.



Potatoes. Most Welsh farms grow a small area of potatoes primarily for farm consumption, but in every district there are some farmers growing for local sale. The quantities grown for sale in the larger and distant towns are small compared with those grown in some districts of England. In North Wales production on a fairly large commercial scale is confined to some districts of Flint and Denbigh, although it is pursued on a smaller scale for similar purposes in the Lleyn Peninsula. In South Wales there is little development of commercial production, although there is a little in South Cardiganshire. Very few of the potatoes from the farms of the Principality travel more than 20-30 miles to their final destination, although far the greater number of farms are farther away from the large consuming centres. Probably most of the potatoes are consumed within 5-10 miles of the farms on which they are grown. But the supplies are not even large enough for all the local towns, and English supplies are distributed in most of the smaller towns at certain seasons of the year. Small quantities of very early varieties are grown on the South and West Coast, chiefly for local consumption, and later earlies are grown for commercial sale in the North-east. Second-early or mid-season crops are marketed round all the small towns and sometimes sold in larger quantities in the North-east. While the total population of Wales has been growing the production of potatoes has been diminishing and the deficiency has been made up by English, Irish and sometimes Continental supplies even of the main crop varieties. Thus while the potential demand has been increasing the production has been showing decline. Taken all over the country this is probably due to the diminishing requirements for feeding the farm families, although in some areas sales are probably smaller than they used to be.

Prices of potatoes in Wales have not been specially depressed, and in view of the cost of transport on English supplies it is rather difficult to account for lack of interest in the crop. Such gluts as occur are chiefly found in the North-east where market conditions are mainly determined by supplies from English areas. Small local gluts also occur for short periods in other areas, but these are due to lack of organisation for reaching larger markets.

Swedes and Mangolds. Although on farms situated near towns swedes are sold for human consumption in small quantities, the proportion of the crop sold would be low. Prices are sometimes good when other vegetables are very scarce, but on the whole the price realised has probably not advanced in line with those of other produce for a given area. In the main, the swede

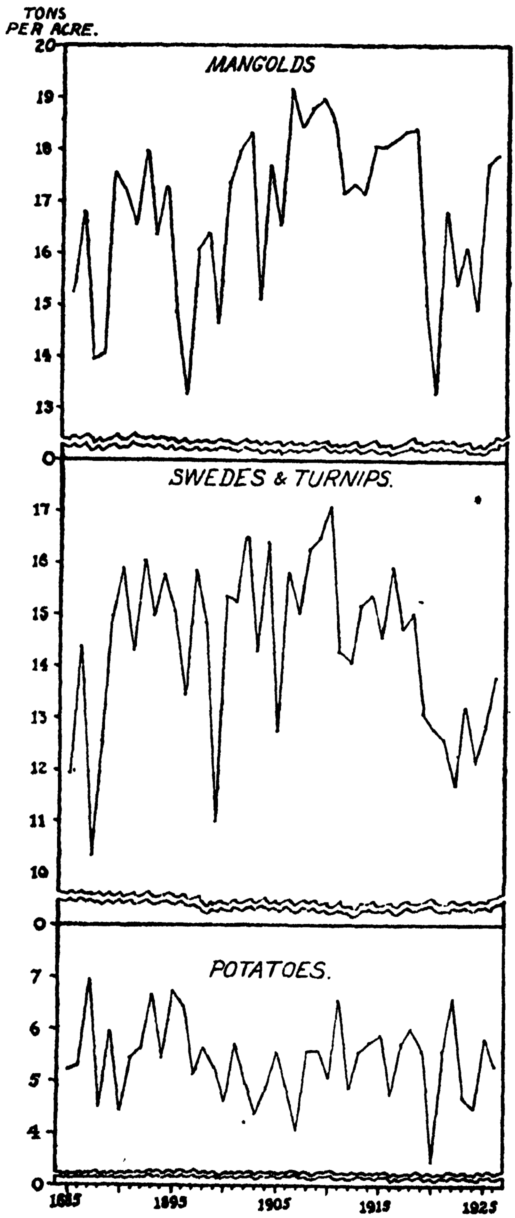
crop is consumed on the farm, either for the production of meat or milk. A small proportion of the mangold crop may also be sold from producing farms to others, but in the main it is consumed on the farms on which it is grown and in all cases is used for stock feeding.

The use of roots for stock feeding may be subject to various influences. If the traditional usage in feeding roots continued and numbers of live stock increased, as they have, it might have been expected that the acreage or total quantity of roots used would also have increased. On the other hand, changes in methods of feeding stock will affect the requirements of roots, and such changes may arise out of the supplies and prices of other feeding stuffs. Undoubtedly, the amounts of oil-cakes and meals, especially of a compound character, used on farms has increased during the last twenty-five years. The prices at which purchasable, and convenience in use, have together proved attractive to farmers. The change has been made on grounds of general opinion and without much definite information on relative costs of roots and other feed stuffs, yet on the whole it appears to have been a sound one. But as stated above, the " cleaning " aspect of the cultivations of swedes has been important in the determination of the acreage grown, and the quantities of mangolds used has slightly increased. The latter change is probably due to a greater use of the crop for dairy cattle but may also have been due to some extent to the greater economy of growing mangolds rather than swedes when grown chiefly for feeding purposes. The tendency towards reliance on purchased foods is on the whole becoming stronger, and the opinion that livestock can be wintered successfully without a supply of roots is becoming both more definite and general. The open expression of this opinion is to some extent the result of recent propaganda and discussion, but it was widely held in latent form before the more public discussions began.

Yields. Figure 2 shows the annual variations in the average yield of root crops for Wales from 1885 to 1926. The most important factors affecting yields would be the yearly variations in rainfall, sunshine, and frost, and the distribution of the first two over the growing season of each year. Mangolds, turnips and swedes for the same years have been influenced in the same direction by these factors, but not to the same extent. The range between the highest and lowest yield average for the different years for the mangold crop was six tons for the whole period, while the range for swedes is approximately seven tons.

FIG. 2.

Average yield per acre of Potatoes and Root Crops for Wales, 1885–1926.



Relative to the actual weight of the crop per acre the variations in yields of potatoes have been greater than for the other root crops.

In the case of mangolds, and swedes and turnips, the general trend of yield shows a gradual rise from 1895 to 1910, and a fall to 1926. An average of years for the potato crop on the other hand seems to be stationary at about 5½ tons per acre.

The chart above gives no indication of the variations in yield for different farms in the same year. The proportion of Welsh land suitable for mangolds is not high, and the farmers' estimate of yields for 1927 on twenty Welsh farms varied between ten tons and fifty tons. These estimates were based on the number of loads carted per acre and on weights varying from 10 to 15 cwts. per load according to the size of carts used.

Under Welsh conditions swedes and turnips are unreliable crops. If suitable weather prevails at sowing time a fair crop can be expected, but a dry spell at sowing time may result in total failure on many farms, as has often been the case during the last few years. On the whole the mangold crop is a fairly safe proposition. And despite variations in yield from farm to farm and from year to year the potato crop is fairly reliable. As regards the acreage planted and that from which a crop is eventually taken, swedes and turnips show the greatest risk.

Influence of Production Costs on Acreage.

Cost of production per acre has no significance apart from yield and price, or value received, as a determinant of the acreage devoted to the crop. Production of potatoes has increased in England because consumption increases with the increase in population and because yield and price have on the average been high enough to cover the increased cost of production in areas specially adapted for potato growing. In Wales on the other hand the yield per acre of potatoes is lower than for England. Prices also tend to be lower in the thinly populated areas of the Principality and these two factors would on the whole tend to decrease the potato acreage where the cost of production may be as high or higher than in the specialised potato districts of England.

Under Welsh conditions the average yield of mangolds, allowing for failures of the swede and turnip crop would be about twice the yield of the latter per acre planted. The food value on the farm for mangolds was estimated at 16/- per ton and for swedes and turnips respectively 16/- and 11/- per ton in November, 1926. Assuming the average costs and yields stated below,

the relative profitableness of mangolds and swedes will be evident, when considering the relation of yield and cost per acre.

	Average Net Cost per acre.	*Average Yield per acre.*	*Cost per ton.*	*Food Value per ton.*
Swedes	£15 0 0	12 tons	25/-	16/-
Mangolds	£20 0 0	25 tons	16/-	16/-

The comparison shows that in the above example 16/- worth of food value in swedes would cost 25/-, whereas in the case of mangolds the cost is equal to the current food value on the farm. It should, however, be pointed out that the weight of feed obtained apart from the percentage of dry matter it contains is no criterion of the feeding value of a root crop. The " food values " in the above comparison are based on the average analyses of mangolds and swedes in England and Wales which are generally used. But there are indications, especially in the case of mangolds, that the food values of the Welsh crop are lower than those usually estimated.[1] More information on this point is required, especially in respect of swedes. But fresh figures for the food contents of the swede crop are not likely to increase the estimated value sufficiently to bring it into line with costs. The interpretation of cost and return figures for swedes must always be made in relation to the place of this crop in the rotation as well as to the necessity of feeding stock.

Variations in Costs.

The following pages comprise a summary of the variable factors which influence the cost per acre of growing potatoes, mangolds and swedes, together with the labour requirements for the different operations on each farm and the analysis of gross and net cost for four groups of Welsh farms.

The records upon which the analysis of Group I is based were obtained by the Survey method. The farmers concerned agreed to keep records of all labour and materials used and expenses incurred in respect of each crop, and furnished a return including these records at the end of the year.

Group 2 (Labour Record) contains six farms for which were kept detailed daily records of all manual and horse labour applied to each department and crop on the farm. In addition to the labour records the quantities and prices of all manures and seeds used together with the amounts of rent and rates paid were obtained.

[1] See this *Journal*, " The chemical composition of mangolds grown in Mid-Wales ", by Fagan and Watkin, pp. 102-113.

1. *Variations in labour hours applied per acre.* The most important variables are the manual and horse-labour hours applied per acre on different farms, the latter being probably the more important of the two. These would be affected by the physical nature and conditions of the soil, slope, and condition with regard to its cleanliness. The distance from the homestead would also account for variations as a result of differences in the time required for hauling out manure and carting in the crop. Yield and size of plot are other factors which influence labour requirements, but the former not necessarily proportionately to its amount. Differences in quality of labour from farm to farm would probably not be very great.

Table I gives a summary of the total manual and horse hours applied per acre to root crops and potatoes on the two groups of farms for 1926.

TABLE I.

Variations in Total Manual and Horse Labour Requirements of Crops per acre.

Farms.	Potatoes.		Mangolds.			Swedes.		
	Manual	*Horse.*		*Manual*	*Horse.*		*Manual.*	*Horse.*
Labour Record Farms—								
1	238½	94		179½	150½		130½	121
2	331	136		301	199½		292½	235
3	254½	219½		544	432		204	162
4	275½	147½		445	415		372	256
5	251½	190½		262½	109		163½	116
6	198	129½		248	141		—	—
Average	258	161		330	241		193½	148
Survey-Farms—			*Farms.*			*Farms.*		
1	228	55½	13	330	180	11	193	91
2	240	118	15	219	116	17	159	133
4	247	147	16	140	93½	24	200	130
12	139	93	18	122	86	—	—	—
14	237½	88½	19	190	190	—	—	—
			21	237	189½	—	—	—
			23	225	115	—	—	—
Average	218½	100½		209	138½		184	118

2. *Variations in cost rate per hour for horse labour.* Apart from the variations in the actual number of hours of labour applied per acre the cost per hour of horse labour is an important variable. Differences in the annual cost of keeping a horse between farm and farm may not be very great, but the number of hours worked per horse on different farms shows a very wide variation, and the rate per hour being determined by the total number of hours worked, divided into the total net cost of keeping a horse, the cost rate per hour becomes a variable in addition to the differences in the actual hours applied per acre.

Estimated variations in the cost per hour for horse labour for six Welsh farms are shown in the following Table. The same total cost of keeping a horse has been used in each case.

TABLE II.

The influence of the total number of Hours worked per Horse on the Cost per hour of Horse Labour. (Labour Record Farms).

Farms.	*Number of hours per horse.*	*Cost of horse labour per hour.*
		s. d.
1	2,525	4¾
2	1,089	11
3	925	1 0
4	986	1 0
5	643	1 6½
6	1,346	9
Average	1,252½	11¼

These variations in cost of horse labour do not specially affect the root crops, for they are common to all horse work on the farms. They are the result of types of farming, with their total horse labour requirements, and of the management and labour policies of the farmers. There is, however, little doubt that with the decline of tillage the unit cost of horse labour often tends to rise; or that with an increase of tillage and roots the cost per hour would fall on several of these farms.

3. *Variations in the net cost of Manures and Fertilisers applied per acre.* These variations depend largely upon the condition of the land, type of soil, and previous cropping and treatment of the land during the normal rotations. There is no method available for the accurate determination of the proportion of the gross application of farmyard manure chargeable to the crop grown in the year of application. Actually all crops do not benefit to the same degree from a direct application, but for this computation the usual charge of one-half has been made against the growing crop in all cases. The deductions from the gross cost of purchased fertilisers taken in order to determine the net cost are based on Hall and Voelckers' Tables.

Table III gives a summary of the variations found.

TABLE III.

Variations in the Net Cost of Manures and Fertilisers applied per acre on the six Labour Record Farms, 1926.

FARM		POTATOES.		MANGOLDS.		SWEDES.	
	F.Y.M. per ton.	*Farmyard Manure.*	*Purchased Fertilisers.*	*Farmyard Manure.*	*Purchased Fertilisers.*	*Farmyard Manure.*	*Purchased Fertilisers.*
		£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1	5/-	3 15 0	—	3 15 0	—	3 7 6	—
2	6/-	4 8 6	1 8 3	4 10 0	4 4 0	4 10 0	1 12 9
3	6/-	2 8 0	0 10 8	3 0 0	0 12 0	3 0 0	1 2 11
4	6/-	2 14 0	—	3 12 0	—	2 5 0	0 10 0
7	4/-	3 0 0	0 10 0	3 0 0	0 13 9	2 0 0	0 15 6
6	10/-	3 15 0	1 5 0	3 15 0	1 9 10	—	—
AVERAGE		£3 6 9	£0 12 4	£3 12 0	£1 3 3	£3 0 9	£0 16 3

4. *Variations in Rent and Rates per acre.* These account for a relatively small variation in costs for the farms under discussion, but a wider range of deviation from the average shown here would be obtained if a larger number of farms were considered. No attempt has been made to differentiate between different grades of land on the same farm in arriving at the rent per acre with the exception of hill and mountain pastures, which have been eliminated from the calculation. The total rent of each farm, with the above exceptions, has been divided by the total number of acres, and furnishes the following figures :—

TABLE IV.
Variations in Rent and Rates per acre.
(Labour Record Farms).

Farm.	*Rent.*	*Rates.*	*Total.*
	£ s. d.	£ s. d.	£ s. d.
1	11 10	2 8	14 6
2	17 6	4 5	1 1 11
3	16 6	3 4	19 10
4	15 0	3 6	18 6
5	11 2	2 10	14 0
6	1 3 0	4 2	1 7 2
Total ...	4 15 0	1 10 11	5 15 11
Average ...	15 10	3 6	19 4

5. *Variations in Establishment or General Work.* These include all labour spent on the general maintenance of the farm and consist of the time devoted to yard work, drainage, farm road work, fences and any other labour which could not be charged directly to a crop or livestock department. The usual practice is to apportion such establishment charges between the various revenue departments of the farm in proportion to the labour expenses in those departments. This method has been adopted in the determination of the amounts chargeable to the root crops below. Mangolds and swedes are considered as intermediate or non-revenue crops, and no charge has been made against them for establishment work.

Potatoes on the other hand, whether consumed by the farm families or sold, are considered as a revenue crop, and a proportion of the establishment work has been charged in each case. Excluding non-revenue crops, the percentage additional charge in respect of establishment work amounted to about 20% of the labour applied directly on the potato crop. A small item for other general expenses might also be added, but as the exact amount is unknown it has been omitted.

6. *Variations in the Cost of Seed per acre.* With the exception of potatoes, where the difference in value between home grown seed and purchased Scotch seed introduces a fairly wide variation in acreage cost, variations in seed costs are not very significant in their effect on costs per acre.

7. *Variations in Yield.* There are two aspects of yield variation which are important to consider, firstly the variations occurring between farm and farm for the same year, and secondly, the variations in the average yield from year to year. The first type of variation shows a much wider range than the latter.

For the seven survey farms showing yields there is a difference of 4.1 tons between the highest and lowest yield of potatoes. Mangold yields vary between twelve tons and fifty tons for the same group, and swedes and turnips show a range of yield variation of ten tons per acre between highest and lowest for the same year. It is this variation in yield between different farms for the same year which is of the greatest importance in a consideration of cost. The second type of variation shown in Fig. 1 is a result of changing weather conditions and changes in the long-time trend of land fertility. Although there may be fairly wide variations in yield for a given crop on the same farm from year to year, the tendency is for the same farm to show a good deal of consistency in the yield of crops.

Those differences in yield which arise out of soil and weather conditions are to a large extent beyond the farmer's control.

Those variations, however, which arise from differences in cropping, manuring, variety and quality of seed and cultural methods of farmers, and which are the chief determinants of the ultimate cost of the crop, are capable of control by each farmer, and the factors of cost can be changed in order to obtain the most economical balance. The time at which each cultural and manurial application to the crop is made is also an important factor in the farmer's control over yield.

General Variations. A consideration of the above variables which enter into the cost of producing crops indicates clearly that costs for a given crop on a number of individual farms have to be scrutinised with care before the information can be turned to account by farmers in general. At best some estimates have to be made in the calculation of the cost of a crop and the reliability of the results will depend on the accuracy of these estimates. For the individual farmer such costs may be of use, when used with care, in the consideration of his rotation or his general policy for the farm.

When, however, a number of crops can be costed on different farms, and the average computed for the group, it is possible to arrive at a close approximation of the truth. " Errors of measurement or observation tend, in the absence of bias, to group themselves about the true value of the quantity measured in such a manner as to eliminate each other in the final average ".

In order to achieve this average which brings us nearer truth, the elimination of " bias " from any estimates which have to be made is first and foremost in importance. It is more likely to enter into survey records taken at long intervals than into detailed day to day records kept on the farm. Second in importance is the number of records made. The greater the number of records entering into an average, the nearer will the average cost be to the true cost of production at a given time. Detailed records of costs of farm products require much of the farmer's time and patience over a long period, as well as a good deal of statistical work later, and these factors impose a severe limitation on the number of records which can be obtained or handled.

It is realised that the number of records in the analysis of root crops presented in this case is low, and that this should be borne in mind in the interpretation of the average costs shown. It may, however, be pointed out that the records were obtained from widely distributed farms, and that the range of variations in cost include extremes both high and low. The average costs given are believed to be fairly representative for Welsh farms for the year in which they were obtained.

Gross Operation Costs per Acre.

Table V gives an analysis of the average operation costs for Group 2 (Labour Record Farms) based on detailed labour records kept on six farms.

A comparison of the total cost of preparatory cultivations for the three crops shows an amount considerably lower for potatoes than for mangolds and swedes. This is partly because the latter crops require a finer seed bed, as is shown by the larger amount of time given to rolling and harrowing for these crops, but the potato land receives less cultivating and cleaning work. Another item of cost which is a good deal higher is the labour required for hoeing and singling the swedes and mangolds.

Lifting and carting forms an appreciable item in all cases, but it is highest for mangolds and lowest for swedes. The amount of labour required for lifting and carting potatoes appears

high, but it must be remembered that the rainfall is often heavy at the lifting season.

TABLE Va.

Average Operation Costs. Potatoes.

(Labour Record, Six Farms).

OPERATIONS.	HOURS.			COST.			TOTAL COST.
	Manual.	*Horse.*	*Tractor.*	*Manual.*	*Horse.*	*Tractor.*	
				£ s. d.	£ s. d.	s. d.	£ s. d.
Ploughing	15.59	30.00	—	0 9 1	1 5 5½	—	1 14 6½
Cultivating	1.00	2.83	.08	0 0 7	0 2 1¾	0 3¼	0 3 0
Harrowing	5.83	12.17	.50	0 3 5	0 12 1	1 9	0 17 3
Rolling	1.17	2.16	—	0 0 8	0 1 10¾	—	0 2 6¾
Manuring	46.62	26.59	—	1 7 2¼	1 2 7	—	2 9 9¼
Cleaning	9.13	9.79	—	0 5 4	0 9 9	—	0 15 1
Total Preparatory Cultivations ...	79.34	83.54	.58	2 6 3¼	3 13 10¾	2 0½	6 2 2¼
Ridging	7.08	14.25	—	0 4 1¼	0 12 9½	—	0 16 11
Drilling	12.29	.58	—	0 7 2	0 0 6¾	—	0 7 8¾
Moulding	4.29	7.33	—	0 2 6	0 4 9¼	—	0 7 3¼
Hoeing and Singling	32.67	13.75	—	0 19 0¾	0 13 0¾	—	1 12 1½
Lifting and Carting	77.41	35.25	—	2 5 2	1 11 7½	—	3 16 9¼
TOTALS	213.08	154.70	.58	£6 4 3¼	6 16 8½	2 0½	£13 3 0¼

TABLE Vb.

Average Operation Cost. Mangolds.

(Labour Record, Six Farms).

OPERATIONS.	HOURS.			COST.			TOTAL COST.
	Manual.	*Horse.*	*Tractor.*	*Manual.*	*Horse.*	*Tractor.*	
				£ s. d.	£ s. d.	s. d.	£ s. d.
Ploughing	19.75	38.33	.50	0 11 6½	1 17 5¾	1 9	2 10 9
Cultivating	9.83	19.33	.17	0 5 9	0 19 4	0 7	1 5 8
Harrowing	13.33	33.00	.17	0 7 9½	1 12 3	0 7	2 0 7¼
Rolling	8.67	16.58	.25	0 5 0½	0 15 8½	0 8½	1 1 5¾
Manuring	57.58	46.17	—	1 13 7	2 1 1¼	—	3 14 8¾
Cleaning	6.33	9.50	—	0 3 8½	0 9 6	—	0 13 2¼
Total Preparatory Cultivations ...	115.49	162.91	1.09	3 7 4½	7 15 4¾	3 7½	11 6 4½
Ridging	11.67	23.25	—	0 6 9¾	1 1 2½	—	1 8 0
Drilling	4.41	3.58	—	0 2 7	0 3 5½	—	0 6 0½
Hoeing and Singling........	122.75	9.67	—	3 11 7½	0 8 9	—	4 0 4½
Lifting and Carting	75.75	41.58	—	2 4 2½	1 17 5¾	—	4 1 8
TOTALS	330.07	240.99	1.09	£9 12 6½	£11 6 3	3 7½	£21 2 5

TABLE Vc.

Average Operation Costs. Swedes.
(Labour Record, Five Farms).

Operations.	Hours.			Cost.			Total Cost.
	Manual.	*Horse.*	*Tractor.*	*Manual.*	*Horse.*	*Tractor.*	
				£ s. d.	£ s. d.	s. d.	£ s. d.
Ploughing	26.2	55.4	—	0 15 3	2 15 7	—	3 10 10
Cultivating	2.2	3.6	.4	0 1 3	0 3 7	1 5	0 6 3
Harrowing	10.1	25.1	—	0 5 11	1 2 11	—	1 8 10
Rolling	4.7	9.4	—	0 2 9	0 9 4	—	0 12 1
Manuring	47.0	27.5	—	1 7 5	1 6 11½	—	2 14 4½
Cleaning	12.6	13.0	—	0 7 4	0 13 1	—	1 0 5
Total Preparatory Cultivation	102.8	134.0	.4	2 19 11	6 11 5½	1 5	9 12 9½
Ridging	6.6	13.2	—	0 3 7	0 12 0	—	0 15 7
Drilling	4.3	3.1	—	0 2 6	0 3 2½	—	0 5 8½
Hoeing and Singling	68.3	8.3	—	1 19 10	0 8 2½	—	2 80½
Lifting and Carting	50.8	20.4	—	1 9 7½	1 1 10	—	2 115½
Totals	232.8	179.0	.4	£6 15 5½	£8 16 8½	1 5	£15 137

An exact comparison of these results with those of the survey farms cannot be made, but the following figures give somewhat similar details.

TABLE Vd.

Mangolds. Seven Survey Farms.

Operations.	Hours.			Cost.			Total Cost.
	Manual.	*Horse.*	*Tractor.*	*Manual.*	*Horse.*	*Tractor.*	
				£ s. d.	£ s. d.	s. d.	£ s. d.
Preparatory Cultivations	69.56	80.67	.68	2 13 1	2 8 7	1 1½	5 2 9½
Seeding	16.06	6.77	—	0 11 4	0 3 8	—	0 15 0
Hoeing and Singling	47.53	3.96	—	1 16 3	0 2 6	—	1 18 9
Lifting and Carting	76.10	47.23	—	2 16 9	1 7 7	—	4 4 4
	209.25	138.63	.68	7 17 5	4 2 4	1 1½	12 0 10½
Swedes. Three Survey Farms.							
Preparatory Cultivations	57.8	81.6	—	2 0 0	2 15 4	5 0	5 0 4
Seeding	8.66	6.87	—	0 6 8	0 4 1	—	0 10 9
Hoeing and Singling	46.	5.66	—	1 7 11½	0 3 10	—	1 11 9½
Lifting and Carting	71.5	23.83	—	2 5 8½	0 15 4	—	3 1 0½
	183.96	117.96	—	6 0 4	3 18 7	5 0	10 3 11
Potatoes. Five Survey Farms.							
Preparatory Cultivations	43.94	52.82	—	1 11 2½	1 13 11	8 11	3 14 0½
Planting	17.51	11.67	—	0 12 4	0 7 7	—	0 19 11
Hoeing and Moulding	26.17	14.46	—	1 0 9	0 9 5	—	1 10 2
Lifting and Carting	130.9	21.8	—	4 9 9	0 14 6	—	5 4 3
	218.52	100.75	—	£7 14 0½	£3 5 5	8 11	£11 8 4½

Analysis of Total Gross and Net Costs for each Farm.

A comparison can be made of each cost factor for individual farms in respect of each crop from Tables VI, VII and VIII, together with the total gross and net cost per acre.

The total gross costs show a variation between the highest and lowest cost per acre as follows :—

Potatoes	...	£13	16	5
Swedes	...	£14	0	3
Mangolds	...	£31	4	0

Farms three and four in Group 2 show an exceptionally high gross cost for mangolds. This is due to a very high cleaning charge in both cases, a large proportion of the cost of which was chargeable to succeeding crops in the rotation. The exceptionally low cost for mangolds on Farm eighteen is due to the low cost of manures and a fairly low cost for all other factors. On this farm the low cost is accompanied by a low yield.

The net cost per acre also shows a range of variation between highest and lowest, the differences being :—

Potatoes	...	£10	18	2
Mangolds	...	£17	11	10
Swedes	...	£ 7	17	1

The deductions from the gross costs made in respect of the residual value of cultivations were determined separately for each farm. All the operations which could be reasonably charged to the root crop are charged to it according to the records of labour used for each farm, while the amount of labour applied which would benefit succeeding crops has been deducted. There can be no set or satisfactory rule for this allocation, and it must at all times remain arbitrary as there is no method of determining how much the succeeding crops will actually benefit from these operations.

A comparison of the average Gross and Net Costs of the two Farm Groups.

The analysis presented in Table IX shows a comparison of average costs for two separate groups of farms in respect of each crop. There is a very close comparison between the gross costs of potatoes in both groups, a difference of £1 8s. 2d. per acre only being shown.

The wide difference in horse labour cost is to a large extent accounted for as a result of the difference in the average cost per hour of horse labour in the two groups.

In the case of mangolds and swedes, horse labour is again the most variable factor.

TABLE VI.

Analysis of Gross and Net Cost of Production per acre of Potatoes for eleven Welsh Farms.

	SURVEY FARMS.					LABOUR RECORD FARMS.					
Farm Number	1	2	4	12	14	1	2	3	4	5	6
GENERAL INFORMATION.											
Previous Crop	Oats	—	—	—	Mixed Corn	Oats	Oats and Wheat	Oats	Oats	Oats and Grass	Oats and Wheat
Charge for Horse Labour, per hour	8d.	9d.	7½d.	7½d.	6¾d.	1/6½	9d.	11d.	1/-	1/-	4¾d.
Charge for Manual Labour, per hour	9d.	7½d.	8½d.	9d.	9¾d.	7d.	7d.	7d.	7d.	7d.	7d.
Value of F.Y.M., per ton	10/-	7/-	15/-	7/6	10/-	5/-	6/-	6/-	6/-	4/-	10/-
GROSS COSTS.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Manual Labour	8 11 4	9 10 11	8 6 0	5 1 9	9 0 11	4 11 7	9 8 1½	5 3 5	7 5 10	6 9 11½	4 6 11
Horse Labour	1 17 2	2 8 0	4 12 0	2 18 2	2 10 5	6 12 6	6 19 6	9 4 3	7 7 0	9 3 6	2 9 3¼
Tractor Labour	0 10 0	—	—	1 5 0	0 9 6	—	—	—	—	—	0 12 3
F.Y. Manure	7 10 0	6 1 4	11 5 0	5 15 0	6 0 0	7 10 0	8 17 0	4 16 0	5 8 0	6 0 0	7 10 0
Artificials	1 7 0	1 7 2	1 7 1½	2 5 6	1 8 9	—	1 19 9	0 16 0	—	0 15 0	1 14 6
Seed	4 0 0	4 19 8	9 11 2	7 18 0	5 10 10	6 10 0	3 12 0	4 16 0	4 10 0	4 10 0	6 0 0
Rent and Rates	2 18 0	2 13 2	2 6 4	1 17 5	1 17 7	0 14 6	1 1 11	0 19 10	0 18 6	0 14 0	1 7 2
Establishment Charges	2 3 8	2 7 9	2 11 7	1 17 0	2 8 2	2 17 9	3 7 11½	3 10 11	3 2 9½	3 8 5½	2 2 8¼
Total Gross Cost	28 17 2	29 8 0	39 19 2½	28 17 10	29 6 2	28 16 5	35 6 3	29 6 5	28 11 1½	31 0 11	26 2 10
DEDUCTIONS.											
Residual Value of Cultivations	1 7 10	1 6 8	2 14 11	2 15 5	3 4 2	3 3 4	2 14 6½	4 16 1	3 7 4½	7 11 10	1 12 5¼
Residual Value of Manures	4 13 0	3 11 2	6 2 1	3 11 0	3 6 2	3 15 0	5 0 0	2 13 4	2 14 0	3 5 0	4 4 6
Total Deductions	6 0 10	4 17 10	8 17 0	6 6 5	6 10 4	6 18 4	7 14 6½	7 9 5	6 1 4½	10 16 10	5 16 11¼
Net Cost per Acre	22 16 4	24 10 2	31 2 2½	22 11 5	22 15 10	21 18 1	27 11 9½	21 17 0	22 9 9	20 4 1	20 5 10¾
Yield per Acre—Tons	8.7	9.6	6.6	10.0	10.7						
Cost per Ton	2 2 8	2 10 10	4 14 0	2 5 0	2 2 5						

TABLE VII.

Analysis of Gross and Net Cost of Production per acre of Mangolds for thirteen Welsh farms.

	SURVEY FARMS.							LABOUR RECORD FARMS.						
Farm Number	13	15	16	18	19	21	23	1	2	3	4	5	6
GENERAL INFORMATION.													
Previous Crop	Oats	—	Clover	—	—	—	—	Oats	Oats and Wheat	Oats	Oats	Grass	Oats and Wheat
Charge for Horse Labour, per hour	7½d.	9d.	7½d.	7½d.	7½d.	5d.	7d.	1/6½	9d.	11d.	1/-	1/-	4½d.
Charge for Manual Labour, per hour	11½d.	10½d.	8d.	9d.	9d.	8½d.	7½d.	7d.	7d.	7d.	7d.	7d.	7d.
Value of F.Y.M. per ton	5/-	6/-	6/-	5/-	5/-	8/-	6/8	5/-	6/-	6/-	6/-	4/-	10/-
GROSS COSTS.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Manual Labour	15 9 5	7 18 8	4 17 3	4 11 4	7 7 0	8 1 10	7 0 8	5 4 8½	8 15 7	15 17 4	12 19 7	7 13 1½	7 4 11½
Horse Labour	5 12 6	4 7 3	2 18 4	2 13 9	5 18 9	3 19 8	3 5 10	11 12 0	7 9 7½	19 16 0	20 15 0	5 9 0	2 15 10
Tractor Labour	—	—	—	—	—	—	0 7 11	—	—	—	—	—	1 2 9
F.Y. Manure	7 6 8	6 0 0	3 0 0	2 10 0	2 10 0	4 19 0	7 16 9	7 10 0	9 0 0	6 0 0	7 4 0	6 0 0	7 10 0
Artificials	1 10 9½	2 0 0	3 16 6	0 16 0	1 0 0	2 6 4	1 5 6	—	4 18 6	0 18 0	—	1 0 8½	2 0 6
Seed	0 5 0	0 7 6	0 12 0	0 8 0	0 12 0	0 11 7	0 13 6	0 10 6	0 12 0	0 8 0	0 6 0	0 8 3	0 6 8
Rent and Rates	2 6 6	2 3 10	1 17 10	1 16 1	2 7 10	1 7 1	1 10 0	0 14 6	1 1 11	0 19 10	0 18 6	0 14 0	1 7 2
Gross Cost per Acre	32 10 10½	23 7 3	17 1 11	12 15 2	19 15 7	21 5 6	22 0 2	25 11 8½	31 17 7½	43 19 2	42 3 1	21 5 1	22 7 10½
DEDUCTIONS.													
Residual value of cultivations	3 5 10	3 1 11	1 12 5	2 1 6	1 19 9	3 12 4	3 2 1	4 9 0½	3 14 4½	14 18 5	12 1 3	4 10 3½	3 5 8½
Residual value of Manures	4 1 8	3 13 4	3 6 9	1 15 8	1 18 4	3 8 0	4 10 0	3 15 0	5 4 6	3 6 0	3 12 0	3 6 11	4 5 8
Total Deductions	7 7 6	6 15 3	4 19 2	3 17 2	3 18 1	7 0 4	7 12 1	8 4 0½	8 18 10½	18 4 5	15 13 3	7 17 2½	7 11 4½
Nett Cost per Acre	25 3 4½	16 12 0	12 2 9	8 18 0	15 17 6	14 5 2	14 8 1	17 7 8	22 18 9	25 14 9	26 9 10	13 7 10½	14 16 6
Yield per Acre—Tons	40	50	22.5	12	16.8	36	50						
Cost per Ton	0 12 7½	0 6 8	0 10 9½	0 14 10	0 18 10½	0 7 11	0 5 9						

TABLE VIII.

Analysis of Gross and Net Cost of Production per acre of Swedes for eight Welsh Farms. 1926.

	SURVEY FARMS.			LABOUR RECORD FARMS.				
Farm Number	11	17	24	1	2	3	4	5
General Information.								
Previous Crop	Grass	—	Oats	Oats	Oats and Wheat	Oats	Oats	Oats and Grass
Charge for Horse Labour, per hour	9d.	7½d.	7d.	1/6½	9d.	11d.	1/-	1/-
Charge for Manual Labour, per hour	7½d.	9d.	7d.	7d.	7d.	7d.	7d.	7d.
Value of F.Y.M. per ton	7/6	10/-	6/-	6/-	6/-	6/-	5/-	4/-
Gross Cost.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Manual Labour	6 6 3	5 15 5	5 19 6	3 16 0½	8 10 7½	5 19 0	10 16 11½	4 15 4½
Horse Labour	3 8 6	4 3 0	3 14 4	9 6 7½	8 16 3	7 8 6	12 16 0	5 16 0
Tractor Labour	—	0 15 0	—	—	—	—	—	0 7 0
F.Y. Manure	6 18 5	5 0 0	3 12 0	6 15 0	9 0 0	6 0 0	4 10 0	4 0 0
Artificials	—	3 0 8	1 4 4½	—	2 3 0	1 12 7	0 15 0	1 2 6
Seed	0 6 0	0 8 0	0 5 0	0 4 6	0 6 0	0 8 0	0 6 0	0 4 6
Rent and Rates	2 12 3	2 5 3	1 7 0	0 14 6	1 1 11	0 19 10	0 18 6	0 14 0
Total Gross Cost per Acre	19 11 5	21 7 4	16 2 2½	20 16 8	29 17 9½	22 7 11	30 2 5½	16 19 4½
Deductions.								
Residual Value of Cultivations	1 16 5	1 13 9	2 17 8	2 9 5	6 8 2	4 6 2	9 18 9	2 15 10
Residual Value of Manures	3 7 6	3 17 4	2 12 3	3 7 6	5 0 3	3 9 8	2 10 0	2 7 6
Total Deductions	5 3 11	5 11 1	5 9 11	5 16 11	11 8 5	7 15 10	12 8 9	5 3 4
Net Cost per Acre	14 7 6	15 16 3	10 12 3½	14 9 9	18 9 4½	14 12 1	17 13 8½	11 16 0½
Yield per Acre—Tons	28.8	20	18.7					
Cost per Ton	0 9 11½	0 15 9½	0 11 4					

TABLE IX.

Analysis of the Average Gross and Net Cost per acre for Potatoes, Mangolds, and Swedes. 1926.

	POTATOES.		MANGOLDS.		SWEDES.	
	Five Survey Farms.	*Six Labour Record Farms.*	*Seven Survey Farms.*	*Six Labour Record Farms.*	*Three Survey Farms.*	*Five Labour Record Farms.*
GENERAL INFORMATION.						
Charge for horse labour per hour ...	7¾d.	11¼d.	7d.	11¼d.	7¾d.	11¼d.
Charge for manual labour per hour ...	8½d.	7d.	9¼d.	7d.	8d.	7d.
Value of farmyard manure per ton ...	9/10	6/2	6/-	6/2	7/10	5/2½
GROSS COST.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Manual labour ...	8 2 2	6 4 3½	7 18 0	9 12 6½	6 0 5	6 15 7
Horse labour ...	2 17 2½	6 19 4½	4 2 3½	11 6 3	3 15 3	8 16 8
Tractor labour ...	8 10½	2 0¼	1 1½	3 9½	5 0	1 5
Farmyard manure ...	7 6 3	6 13 6	4 17 6	7 4 0	5 3 6	6 1 0½
Artificials ...	1 11 1½	17 6½	1 16 5½	1 9 7½	1 8 4	1 2 7½
Seed ...	6 7 11	4 19 8	9 11	8 7	6 4	5 9
Rent and Rates ...	2 6 6	19 4	1 19 10½	19 4	2 1 6	17 9
Establishment and other expenses ...	2 5 7½	3 1 9				
Total gross cost ...	31 5 8	29 17 6	21 5 2	31 4 1½	19 0 4	24 0 10
DEDUCTIONS. ...						
Residual value of cultivations ...	2 5 9½	3 17 7	2 13 8½	7 3 2	2 2 7	5 3 8
Residual value of manures ...	4 4 8	3 12 0	3 4 10	3 18 4	3 5 8	3 7 0
Total deductions ...	6 10 5½	7 9 7	5 18 6½	11 1 6	5 8 3	8 10 8
Net cost per acre ...	24 15 2½	22 7 11	15 6 7½	20 2 7½	13 12 1	15 10 2

N.B.—Labour Record costs are for West Wales farms, while Survey costs are chiefly for North Eastern farms, and lower costs are partly due to better farming conditions.

The preceding discussion of the variations in the factors affecting costs was directed chiefly to those which arise between farm and farm. The same variations would also be found in the case of root crops from year to year on the same farm, but in all probability not to the same extent. The soil may vary as much in physical characteristics on different fields within one farm as between different farms. Variations in temporary climatic conditions would also be important. Differences in the amounts of materials, especially manures, would be found, and a good deal would depend on the previous cropping of the land. The general management of labour would probably not change very greatly on the same farm from year to year, but the cost rate for horse labour may show considerable changes.

To the farmer the comparative gross costs per acre would perhaps be the most significant consideration. The deductions made in order to arrive at a net cost are in all cases arbitrary, there being no accurate measurement of the true residual value to the succeeding crops. Furthermore, bad weather may cause a crop failure the following season, and such residual values may be of more importance theoretically than practically.

It may be noted here that the labour expended on the marketing of potatoes has not been charged in the above analysis. This crop was not sold on all farms, and some of those showing sales did not deliver their sales. In order to facilitate comparisons in the cost of growing the crops, marketing has been omitted in all cases.

For the Survey farms yields are shown and the cost per ton is given. Accurate yields, however, could not be obtained for the Labour farms.

Summary.

To summarise, the cost of a root crop is a complex sum into which enter a number of factors varying in cost independently of each other. On a given farm some factors may be used economically while others are used wastefully. Attention should be directed by the farmer to these factors, especially to such as manual and horse labour, which usually form the largest proportion of costs. The cost of labour will depend on the planning and supervision of the whole working force of the farm for the full year and the skill of the farmer in directing his whole labour force into productive uses. The average annual wage of a regular farm worker is about £78, and the farmer has to meet this bill whether the worker is usefully employed for every possible hour or whether he spends only 75% of his possible time on productive work. Most farmers pay considerably more for fifty hours of

work than they do for a fifty-hour week. More important still is the utilisation of horse labour to its full capacity.

It is realised that immunity from the vagaries of weather, or factory precision, cannot be obtained with regard to farm crop work. What is aimed at is the direction of attention to possible economies in the production costs of crops arising from the efficiency or otherwise with which the farm as a whole is organised.

Economy in crop production may sometimes lie in the use of less of some of the expensive factors, e.g., where yield does not correspond to the amounts of these factors used. At another time an increase in cost due to the use of labour or materials, such as fertilisers, where the farmer knows from experience that such an increase will give a more than proportionate yield, may lead to true economy. It is the physical quantities of the various factors used in production, together with their value or cost per unit of product obtained that indicate efficiency.

The only indicator which a farmer can follow in planning his production of saleable products is the market price. It is the relationship of cost and price which determine his profits eventually, and a knowledge of cost and control of cost is all important.

Root crops grown for meat or milk production should be considered from the point of view of the relation of yield to cost, but together with a consideration of yield, the composition or food value per unit of the crop is an important factor.

Apart from the usual variables in costs the size of plots seems to be an important one in the case of root crops on Welsh farms. In some cases late turnips find their way into the cropping schedule of the farm because the inclemency of the weather or lack of time has prevented the introduction of the crop originally planned. Very often the inclusion of a root crop enables the farmer to utilise land and regular labour more fully, and in such a case, although considered by itself an unprofitable crop, it helps to bring down costs in other farm departments. Crop costs are incurred a considerable time before the value of the product is determined and the use of historical cost involves sound forecasting of future values in order to be really useful.

In the case of the crops grown for cleaning and maintaining the condition of the land, especially swedes, the true costs and results are only interpretable in relation to the results of the crop rotation as well as the costs and results of the feed supplied to livestock.

THE PRODUCTION AND MARKETING OF WOOL IN WALES.

By Arnold N. Shimmin, M.A.,
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The main purpose of this article is to give first a brief summary of the wool producing areas of Wales, particularly with reference to the methods of disposing of the clips and secondly to indicate in a little greater detail the uses to which the wool of the hardy Welsh mountain sheep is put in the manufacturing districts of Great Britain.

Throughout the Principality there is a lower proportion of arable and a higher proportion of permanent grass land than in England, and throughout hill and valley are complementary to a degree not frequently found in England. There are many systems of managing flocks of sheep, and although the Welsh mountain breed is most prominent there are many flocks of other breeds and considerable numbers of cross-bred sheep. Details of distribution cannot be given, but the general position may be indicated for each area.

North Wales.

If density be taken as measure, Anglesey is the most important cattle district in England and Wales, but there are also a good many sheep. Some of these are horned Wiltshires, which produce wool only in small quantities and of poor quality. The rest come down from the hills upon the mainland and are crossed with Shropshires or South Downs. The flocks in the area are small, ranging from about 20 to 300. Wool is usually washed and locks are generally packed in the fleeces. It is admitted that the farmers are very much in the dark when they come to sell their wool, but at selling time they do try to follow prices in the press only to discover that press quotations, as compared with those offered by dealers, are more favourable because the press figures, they are assured, relate to graded lots. Many of the buyers here work on commission for some outside firm. Buyers also come from Portmadoc, Newtown, Galashiels and Bradford. A weighing day is appointed and the wool is paid for as it is brought in to the appointed place. The buyers occasionally act as bankers by advancing money on the clip when it is ready and paying the balance on delivery. The growers seem afraid that auctions would not improve their chances of disposing of the wool, as they are under the impression that they would get no more buyers than they have now.

Caernarvon is mainly devoted to pastoral farming, although there are more mixed types on the Lleyn Peninsula. Sheep farming follows the Welsh type, flocks, taking upland and lowland together, vary from quite a few sheep to as many as 3,500. The typical crosses are Cheviot and Shropshire, but there are also some pure bred South Downs, and the local breed in Lleyn. The wool is washed and is still sheared by hand. There are no auctions in this area,[1] the wool being disposed of by one of two methods. Buyers from Dolgelley and Pwllheli buy wool and sort it into four or five grades for supply to local mills or other merchants. There are also local agents and merchants who come round buying wool for a commission of a farthing a pound. As in other districts a weighing-in day is appointed at some convenient place. Farmers bring in the wool, see it weighed, and are paid by the principal of the purchasing firm who attends for that purpose. There is apparently little effective competition between the wool stapler and the commission agent.

In Denbigh the sheep country is on the uplands between the valleys of Clwyd and Conway. The great majority of the flocks are Welsh, but many breeds and crosses are to be found. The Border Leicester, South Down, and Suffolk crosses are common in flocks of from 70 to 300/400. Although wool washing is declining it is still very common. About 80% of the wool in the district is sent to auction and some unfortunate experiences of local farmers in selling wool to unscrupulous private buyers against small deposits are expected to increase the popularity of the local auction. The auction of wool at Llangollen is said to have forced up outside prices by as much as 3d. per pound in its first year. The selling charges are rather high, but the seller gets 25% of the value immediately. It is understood, however, that the auctioneer is covered in these transactions by an advance of 40% of the price from the buyer. Sometimes a reserve price is put on the wool when it is not possible to enforce the reserve because few of the farmers are too far away to take their wool back again if they should not succeed in making their price. The private purchases for cash at over-all prices take place before the auctions here, which come rather late in the year, and this meets the requirements of weak holders of wool. It is not uncommon for auctioneers to take the clip against debits for stock on their books, a makeshift method of finance to which they are driven by the lack of proper credit arrangements. The

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[1] A Wool Co-operative Society was in operation some years ago but has been wound-up.

local mills which used to buy for cash down are mostly closed now.

In Flintshire the trend is apparently more and more towards dairying and the flocks of sheep vary appreciably in size from year to year. The chief breeds are Welsh and Kerrys, though there are a few flocks of Leicester and South Down. The crosses cover a wide range from Dorset, Ryeland, Hampshire, Shropshire, Suffolk to Cheviot and Scotch Blackface on Welsh ewes. The wool is all sold unwashed and much of it goes to auctions at Chester (where there is a selling charge of 5% and two pounds per hundredweight draft) and Wrexham. Occasionally outside buyers operate privately, but the growth of the auction system has practically put a stop to this. There are, however, some firms who act as "collectors" or buying agents for outside firms. In addition there are the purchases made by the Holywell Textiles Ltd. There is some grading of wool when the farmer brings it in, but the system of classification used suggests more accurate grading than actually occurs. For example, a Welsh-Cheviot cross may be classified into "Welsh", "Cheviot" or "Welsh Cheviot" according to its nearness to type, thus giving three classifications for what is substantially one wool.

Merioneth is a mountainous district interested particularly in cattle and sheep. The flocks are large and mainly of the Welsh mountain type with very few crossbreds. The wool from the district is generally sold washed. Some of it is bought for local consumption, but a good deal is collected by local agents, who work on a farthing per pound commission for Bradford users. Prices change very slowly, but the growers do their best to follow the markets through reports in agricultural journals. There are no auctions in this part of the country and the growers are not attracted by proposals to start them because, they point out, there is no effective alternative if the market is against them. Distances are great owing to the absence of railways, so that once the wool is pitched it has to be sold. Their only weapon against falling prices is to hold the wool and this is not a very satisfactory proceeding. It is of interest to note the opinion in this part of Wales that the lot of the wool producer would be improved if more wool were worked up locally instead of being taken away such long distances. This view is typical of the misunderstanding of the economics of centralised large scale production, the history of the woollen industry and the limitations of Welsh wool itself. But perhaps one ought to reflect that these hill-side farmers are in many instances too remote from conditions of industry and commerce to appreciate

the strength of the economic forces that are steadily working against them.

In Montgomery, a county of extreme variety in farming, an experiment in co-operative sale of wool has been tried. The producers collected and graded their wool and tried to sell it at Newtown auction, but a boycott amongst the buyers brought disaster to their efforts. There are still two auction sales in the South, largely used by private buyers as a guide to prices, but apparently very little of the hill wool is sold at these auctions. The hill farmers prefer private settlements and will hold their wool for considerable periods if they think they can get a rise in price. Shearing occurs late in the year, but most of the wool in the market is bought by local merchants before Christmas. They still shear by hand and wash their sheep.

South Wales.

In Cardigan, farming is mixed but an important part is the breeding and rearing of stock and sheep. The hills provide pasture in the summer and the winter exodus to the lowlands is reinforced by emigrants from Breconshire. The lowland farmers concentrate upon improved Welsh, Suffolks, Hampshires and their various crosses. Their flocks range from 20 to 200, whereas hill flocks in this area are 1,000 and over.

Wool marketing in Cardigan reveals the three main types of selling to be found in Wales, private buying, local auctions (as for example at Lampeter), and buying by the local textile manufacturers for their own use. The gradual decline of the third type of purchase is the natural outcome of the decay of Welsh manufacture, which has already been adequately described by Mr. Crankshaw[2] and Miss Anna Jones.[3] In the industrial areas the Welsh native flannel has been ousted by the finer finishes of West of England and Yorkshire cloths. This, however, should not lead us to overlook the fact that these small local manufacturers in Cardiganshire are an important part of the machinery for disposing of wool. Frequently they act as agents for Bradford buyers when they are not buying for their own use and they buy with greater knowledge of qualities than the farmer-agent who is so common in Wales.

In Carmarthen there is also a large industrial area but still a fair number of sheep and the hill flocks are, as usual, large. There is a plentiful supply of water and it is asserted that prac-

[2] W. P. Crankshaw. "The Welsh Textile Industry". University of Wales Press.

[3] A. M. Jones. "The Rural Industries of England and Wales", Vol. 4, Wales. Oxford University Press.

tically all the wool is washed. In this area we can detect the endeavour of the young keen farmer to alter the old custom of direct personal purchase of wool. Under this system it has become almost a family tradition to sell one's wool to the people who have bought it from the family for years and any variation of this practice would involve personal slights. This type of thing may have been satisfactory when the demand from the local mills exceeded local supplies of wool, but with the decline of the mills local demand has been unimportant for many years. Hence the interest attaching to developments in marketing that have been initiated by the farmers themselves. A few of them have their wool graded and sell it in Bradford. Others again, with comparatively small clips, have put their wool in the hands of the London selling brokers, but most interesting of all is the Carmarthen National Farmers' Union experiment in auction sales. These sales were begun by the National Farmers' Union and are controlled by an active wool sales committee. By careful arrangement with the British Wool Federation, and the auctioneer, and by advertisement locally and in Bradford, they have succeeded in attracting sufficient buyers, though the number of fleeces offered at a representative sale is only about 1,500 sacks of eight or ten fleeces each. By educating the members of the Union on the better preparation of the wool for market it is hoped to retain the interest of buyers in the fleeces offered. Packing is still a serious problem because the sacks used are often ordinary grain sacks and this detracts from the showing of wool to the greatest advantage. The auctioneer's commission to sellers is slightly higher than in England but less than in many other parts of Wales. It will be interesting to follow the efforts of the Carmarthen farmers to improve the sale of their goods by careful attention to grading and packing.

In Pembroke, one of the most important agricultural counties in Wales, there are two auction sales for wool, although a good deal is still bought privately on Bradford account. Buyers attend the markets and sometimes buy without even seeing the wool although they are not slow to send in claims for rebate if they find that quality is not equal to expectations or that they have been deceived. The seller is instructed to send his wool along and the local agent arranges full truck loads for despatch to his Yorkshire principal or customer. It is quite easy to get several quotations for wool, but as they are always the same from each source it is hardly worth the trouble. Moreover as everybody expects to get the same price as everybody else the best man has little incentive to maintain his superiority

and the worst man has no incentive to improve his goods. Local mills at one time used to finance these growers when they needed it and take their wool in settlement of the account. These mills still use a little local wool, but they buy it by the ordinary method of direct purchase or at the auctions.

In Brecon and Radnor there is a large and important sheep country. The system of sheep farming depends very largely upon the proportion of common or un-enclosed land, but stock and sheep production are the prominent agricultural pursuits. There are a few large flocks but 500 is a common figure and on the lower ground 150 is reckoned a good sized breeding flock. It ought not to be overlooked that the larger flocks tend to be pure bred Welsh or improved Welsh, though frequently there are slight differences between flocks which associate them with their particular hills. Lowland flocks as distinct from hill flocks are increasing and include Kerry-Hill and Shropshire, the Welsh crossed with Cheviot and Kerry. The shearing of wool in this area is still mainly done by hand because the machines are said to clip the hill sheep too closely. Men are trained for the work of shearing and specially organised classes and competitions are established to maintain interest in the work of shearing. It is unfortunate that the wool is not got up very well, largely owing to the presence of straw and chaff acquired during storage in local granaries. The wool is bought privately by dealers from Newtown and Leicester, in the main on the flat-rate principle, though breeds are roughly classified. One illustration will suffice to show how rough this classification may be. One farmer sent his wool, a Cheviot-Welsh cross, to the Scottish auctions, paying carriage and selling charges, because if he had sold locally all his wool would have been classed as Welsh owing to its kemp. In Scotland some of the wool was classed as Cheviot and only the kempier sorts as Welsh, and his extra costs were easily covered by the higher price received for the Cheviot type. The enterprise of this man cannot, unfortunately, be imitated in all cases because it would be difficult for many people to wait so long for their money as is necessary when it is sent to public auction in Scotland. Usually they prefer private sale with quicker payment even though the total return may not be so good.

Monmouthshire, for some reason or other, seems to be viewed as the appropriate dumping ground for everybody's surplus, rather brutally it is sometimes urged that " anything is good enough for the miner ". But there are one or two points of interest. The flocks are small and only about 15% of the wool

is said to be sold unwashed. Local auctions were tried at Monmouth for a couple of years but they did not arouse the keen interest of the growers. Some of them, however, consign their wool to Scottish brokers for sale, though much of it is kempy. The largest local buyer grades his purchases into about twenty classes and sells fleece-wool to Carmarthen, North Wales, Bradford and Scotland (where large quantities are bought for tweeds and blanket making). Some years ago an experiment in co-operative marketing was tried in this area. The wool was bulked and graded and sold in Bradford but the market went against the growers and this interesting experiment collapsed.

Uses of Welsh Wool.

This brief survey has brought to light two important points. First, that although a great part of the wool produced within the borders of Wales may be classed as Welsh wool there is intermixture of breeds, and many crosses in nearly all areas. Some of these breeds are common in England and the crosses also are the same as those used for similar purposes in other parts of Great Britain. The other breeds and crosses will, on the whole, give heavier clips than the flocks of Welsh sheep. And, secondly, there is a considerable variety of practice in disposing of the farmers' clips. There is little to which we can point of the order of scientific grading and selling of wool.

It has been estimated that out of a total clip of about six million pounds weight produced within the borders of the Principality not more than two million pounds will represent the production of the true Welsh mountain type of sheep, these two million pounds being worth approximately £100,000. The typical fleeces from the Welsh mountain breed are about two pounds in weight and are marked by two outstanding characteristics, first, the presence of much kemp, and secondly, a peculiarly soft handle. The colour of the wools is almost uniformly good, except in the areas of peat pastures. The fleeces are coarse as compared with typical crossbred or merino fleeces and exhibit a range of qualities from 32's to 56's. At the Welsh end the fleeces are taken by the farmer and submitted to the purchaser exactly as they come off the sheep. There is little or no attempt to class or grade the wools. On many farms the number of fleeces is too small for effective handling in this way. In other cases the farmer does not appreciate the manufacturing possibilities of the various parts of the fleeces. Sales take place at local auctions at which staplers from various parts of England and Scotland will compete for the wool or alternatively, sale is by direct dealing

with the farmer on the part of the wool stapler. There are many such staplers in Wales and Bradford and these men bring or send the wool direct to Bradford and sort it to about twelve qualities ranging from the coarsest or britch wool to the finest, which will give a good 56's spinning quality. Attempts to encourage grading on the part of the farmers and pooling of their clips have not been successful. This is explained partly by traditional connections with customers and partly by the suspicion on the part of the farmer of the method of public auction. One must bear in mind also the possibility of a variety of wools from one farmer's clip.

After the wool is graded or sorted in this way it is traded to five principal areas outside the Principality. First, the tweed making area of the Colne Valley; secondly, to Scotland, where the wools are blended with other wools for the production of Scotch tweeds; thirdly, the blanket trade of Lancashire and Yorkshire; fourthly, Germany, where, during the last three years or so, there has been an appreciable increase of consumption of Welsh wools for much the same purpose as they are used in this country; fifthly, America, where the longer and coarser part of the fleece comes in for use in the carpet trade.

As the slight harshness of the kemp in Welsh wools gives a peculiarly rough surface to the fabrics in which they are used, it will be seen that the outlet for such wool is largely dependent upon fashion based upon rougher surfaced cloths. A few years ago, when frieze cloths were all in fashion, Welsh wools were bought extensively for securing this rough surface. With the decline in popularity of frieze a new outlet has been found in the development of the tweed trade, particularly sports tweeds, plus-four suitings, motoring tweeds and the like. The finest qualities of Welsh wool may be used for the manufacture of high grade ladies' tweeds, but as the proportion of fine wool, free from kemp, in any fleece is small, the trade is not an extensive one. The decay of Welsh manufacture, in particular the manufacture of the flannels formerly so widely used by the Welsh miner, has tended to increase the export of Welsh wools and in the opinion of expert wool staplers an increasing proportion is crossing the border and being bought for the purposes indicated above. Quite apart from the coarse nature of the native Welsh flannels, the persistence of primitive method of manufacture goes far to explain the decline of the native Welsh industry.

To-day's price of Welsh wool (ex. farm) is about 18d.[4] per pound. This price is based on the average prices which the wool

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[4] November, 1927.

stapler estimates he will be able to secure for the various qualities of fleece when they are graded or sorted. Between the lowest and the highest qualities of the sorted wools there may be as much as 10d. a pound difference. One stapler pointed out to me that if Welsh wool could be freed from kemp its value might be increased by as much as 6d. a pound, but he was quick to remark that the kemp could not be extracted for such a figure and in some cases if you took all the kemp there would be precious little left. The prices for Welsh wool are what we may term open market prices inasmuch as it is used for blending with other Scotch or English types and changes upwards or downwards are normally in sympathy with similar rises or falls in other grades of wool in the open market. In other words, the peculiarities of Welsh wool are not so marked as to enable it to establish a private market. It must be regarded as a type of wool complementary to other types within the ranges of quality specified but possessing in its kemp a characteristic which limits it more rigidly than other types to certain kinds of manufacture, for example, the frieze cloth or the present-day tweed. Welsh mountain wool is not of use for underwear as produced in the Leicester hosiery trade, although it may be of use if fashion runs on frieze-like outer wear. Nor is it a complete substitute for wools of similar quality, say Shropshire, Kerry or South Down, because the kemp refuses the dye which the wool free from kemp will take. The South Down or Kerry wool being free from kemp will dye uniformly throughout.

Hence we may say that kemp is the determining factor in the use of Welsh wool. If fashions prevail in which this quality of surface is required the value of Welsh wool will tend to rise but if outlets are limited by fashion the value will tend to fall.

THE FEEDING VALUE OF MEADOW HAY CUT AT DIFFERENT DATES.

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The practice of leaving meadow hay uncut until late in the season with the object of securing a heavy crop is general in many parts of Wales and elsewhere. To a great extent, experience shows that the practice is based upon fact. The yield of hay on a given field or area at a particular date during the growing season depends upon a number of factors, such as

the character and condition of the land, the rainfall and temperature, and to no small extent upon how late in the spring the field has been allowed to carry stock for grazing. Where heavy stocks of sheep are kept, and particularly in upland districts, it is difficult, and even impossible, to clear the stock off the land at any time until comparatively late in the season and a correspondingly late hay harvest is under normal conditions the result. With other systems of farming, these difficulties do not apply and, assuming normal weather conditions, earlier cutting is possible. There is, however, a general tendency in most districts to cut meadow hay late rather than early simply in order to secure a greater bulk. It has long been known that after a certain stage in its growth, hay, judged by its chemical composition, deteriorates in feeding value. The actual period at which hay possesses its maximum feeding value depends upon the season and, to a less extent perhaps, upon the condition of the land, but in general, late-mown hay, though it may be greater in bulk, is weight for weight inferior in chemical composition to early-mown hay off the same land in the same season. Early and late again are relative terms and vary in meaning according to the situation and climate. So far as the greater part of Wales is concerned, the middle of June may be regarded as early for the cutting of meadow, or old land, hay, while the middle of August, except in upland districts is in normal seasons comparatively late. Very little meadow hay is harvested as early as the middle of June, but taking the country as a whole, a great deal of hay is cut as a general practice after the middle of August.

With the more scientific methods of treating meadows and hay-fields in recent years, persistent efforts have been made to show the advantages of early cutting by directing attention to the deterioration in the chemical composition of hay in the later stages of growth. But while chemical analyses have furnished ample evidence of this deterioration, no data to demonstrate the difference between early and late-mown hay in actual practice were available. With a view to obtaining such data, the writer, when connected with the Agricultural Department of the University College, Aberystwyth, carried out a series of experiments at Tanygraig, then the College Farm. Tanygraig is essentially a stock farm and in this and other respects is fairly typical of Welsh farms in general. It has, however, the advantage over most farms in having unusually good farm buildings so arranged as to be specially suitable for the conduct of feeding trials. The experiments in question were carried

out with sheep and the results, which have until now remained unpublished, are dealt with in the following pages. The object in view was to compare the relative value for feeding of meadow hay cut at different dates. The general plan, therefore, necessitated the cutting on or near the dates fixed upon of a sufficient quantity of hay to feed a number of sheep during the following winter for a period long enough to yield reasonably dependable results. It involved also the provision of suitable accommodation for the sheep to be so fed under such conditions as to make it possible to keep the separate lots under control. Specially designed covered pens with boarded partitions and forming part of the farm buildings supplied the accommodation required.

The Yield and Composition of the Hay.

The hay used in the trials was from the same field each year. The field lies near the farm buildings at an altitude of about 400 feet, and had been regularly mown for hay for many years. The soil, derived from shale, is thin and poor and the herbage was at that time of the mixed character and medium quality generally found on that type of land. It was the practice to winter cattle on the field and these were given hay and a small allowance of cake, but no stock remained on the field after the beginning of March. A strip, consisting of about four acres, along the upper portion of the field was of a fairly uniform character, both as to soil and herbage, and it was from this area that the hay used in the experiments was obtained. It should be understood, however, that it was not from the same plot each year. That was intentionally avoided. For the purpose of the experiments as designed, three plots of hay, representing early, medium and late cutting, were needed and it was decided that they should be mown in the middle of June, the middle of July and the middle of August, respectively. The first year the plots ran, partly by accident, at right angles to the fence; the second year they were arranged to run across those of the previous year; the third year they ran diagonally over the same area; and the fourth year diagonally again in the opposite direction. Roughly, therefore, the hay came from the same portion of the field each year, but each cutting came from a different plot from the corresponding cutting of the previous year. In all respects, apart from the date of cutting, the plots received the same treatment.

The experiments were begun in 1910 and were repeated in 1911, 1912 and 1914. Originally, it had not been intended to continue the trials for more than three seasons, but on considering the results at the end of that period, it was decided to continue

them for a further season. This decision was arrived at, however, too late for arrangements to be made in 1913 and the last of the trials was thus held over until the following year.

The hay plots were each one acre in size and the first year, 1910, they were mown on June 15, July 15 and August 15 respectively. In the subsequent years they were also mown on, or within not more than two days of, these dates on each occasion. The hay was harvested in the ordinary way, weighed on being taken in, and stacked in a hay-shed close to the buildings. The yield of hay is shown in the table following :—

Time of cutting.	*1910*		*1911*		*1912*		*1914*		*Average.*	
	T.	c.	T.	c.	T.	c.	T.	c.	T.	c.
June	1	0½	0	14	0	17¾	0	19¼	0	18
July	1	3	0	15½	1	0½	1	2¾	1	0½
August	1	4½	0	15¼	1	1½	1	4½	1	1½

The crop as will be seen was on the average light, but represented the usual yield from that field, except in the very dry year 1911. The figures bear out the general experience as to the greater weight of late as compared with early-mown hay, except again in 1911, but the gain in weight from leaving the hay till August was much smaller than might have been expected. In 1911, there was an actual loss, but this was entirely due to the drought. The June hay shrank more in the stack than did the July and August hay, except again in 1911, when there seemed to be very little shrinkage in any of the stacks. By good fortune, the weather conditions proved fairly favourable at the time of harvesting in each of the four seasons, and the hay suffered no appreciable damage, with the possible exception of the August hay in 1914 which, owing to bad weather, had to remain in the field for a fortnight. The weather frequently proves disappointing for a period from the end of July to the latter part of August and that is one of the risks connected with late haymaking.

It is hardly necessary to draw attention to the greater amount of aftermath that may reasonably be expected when the hay crop has been removed early. It was so marked in this case that a second crop might have been taken off the June plot in 1910 and 1914 had that been necessary. In practice the aftermath is of much importance, but it was not taken into account of course in these experiments.

At the beginning of the feeding trials, samples of the hay were taken from each of the three stacks and analysed by Mr.

(now Professor) J. J. Griffith, B.Sc., then the Lecturer in Agricultural Chemistry at the College. The percentage composition of the dry matter in the hay is shown in the following tables :—

1910.

	June.	*July.*	*August.*
Crude protein	15·31	14·69	14·73
True protein	10·69	10·11	10·70
Crude fat	2·66	2·47	2·04
Soluble carbohydrate	43·62	46·15	42·09
Fibre	28·85	28·42	32·23
Ash	9·56	8·27	8·91

1911.

Crude protein	13·96	14·13	11·72
True protein	9·84	10·62	10·31
Crude fat	2·46	1·89	1·30
Soluble carbohydrate	44·06	43·82	41·20
Fibre	31·64	31·91	36·42
Ash	7·88	8·25	9·36

1912.

Crude protein	15·04	15·52	14·88
True protein	10·06	10·78	10·89
Crude fat	2·45	2·13	1·91
Soluble carbohydrate	42·88	45·17	39·48
Fibre	29·72	30·72	35·44
Ash	9·91	6·46	8·29

1914.

Crude protein	13·85	14·27	12·21
True protein	9·76	10·42	10·59
Crude fat	2·34	2·01	1·43
Soluble carbohydrate	44·17	42·87	39·54
Fibre	30·91	32·16	37·55
Ash	8·73	8·69	9·27

It will be observed from the analysis that (1) the percentage of true protein was fairly constant for the different months; (2) the crude protein was generally lower in the August hay, this being very marked in 1911 and 1914; (3) the ether extract showed a steady diminution as the season advanced; (4) the soluble carbohydrates also diminished as the season advanced, except in the July results for 1910 and 1912; (5) the fibre content remained

at about the same level in the June and July hay, but there was a marked increase of fibre in the August hay in each of the four years.

The figures seem to indicate a certain connection between the variations in the composition in 1910 and 1912 on the one hand and those in 1911 and 1914 on the other. As a matter having some bearing perhaps on this and other questions, the rainfall in the years concerned may be taken into consideration. The figures given below, furnished by the Medical Officer of Health, show the rainfall at Aberystwyth. They relate to the period of the year which on that particular farm affected the crops most and it is improbable that if the rainfall had been measured at the farm it would have differed materially from that in the town four miles distant.

Month.	*1910*	*1911*	*1912*	*1914*
March ...	1·52	1·89	6·56	4·25
April ...	3·53	1·69	0·18	0·48
Total ...	**5·05**	**3 58**	**7 04**	**4·73**

It has been shown that the best crops as regards yield were obtained in 1910 and 1914. Although it may not be apparent at first sight, the figures given above have a bearing upon this and upon the yield generally. The lowest rainfall was in 1911, which will be remembered as a very dry year after the middle of April, and the drought is reflected in the smallness of the crop for that season. Having regard to the total rainfall, the crop in 1912 was smaller than might have been expected, but it is to be observed that in the period under notice, the great bulk of the rain fell in March and that the period of more active growth was even drier than in 1911. As regards the effect of the rainfall upon the variation in the chemical composition of the hay, the connection, as appears from the analyses, between 1910 and 1912 and between 1911 and 1914 while not so clear, would seem to be borne out, in part at least, by the rainfall figures. The crude protein dropped in 1911 as compared with 1910 and so did the rainfall. Similarly there was a drop in both the crude protein and the rainfall in 1914 as compared with 1912. The ether extract diminished as the season advanced in 1911 and 1914 appreciably more than it did in 1910 and 1912. The soluble carbohydrates were at their highest in the July hay in 1910 and

1912. when the rainfall in March and April was relatively high, but in the June hay in 1912 and 1914, when the rainfall was low. It is not contended that the variations in the composition of the hay were determined by the rainfall, but that it was one of the factors that affected the results would seem to be suggested by the figures that have been given.

The Feeding Trials and their Results.

Experiment I.

The feeding trials with the 1910 hay were conducted during the winter of 1910-11. A sufficient number of Welsh Mountain lambs, a mixed lot as regards sex, from the pedigree flock kept on the farm had been retained for the purpose and at the beginning of the experiment they varied in age from 8 to 9 months. The lambs were housed at the beginning of December and were fed on hay (not from the plots), and an allowance of ½lb. oats and 2lb. pulped roots per lamb per day. Each lamb bore a numbered ear-tag for identification. After being in for nearly a month, the lambs were divided into three lots of ten each according to weight, the number of males and females in each lot being made as nearly equal as possible also, and the experiment began on December 30. The oats and roots were continued exactly as before, and the three lots were in this respect treated alike. But from this date lot I was fed on the June hay, lot II on the July hay and lot III on the August hay. In every respect other than this the three lots received exactly the same treatment. The daily allowance of hay was 10 lb. per lot for the first month when it was increased to 12 lb., or an average of 1.2 lb. per head, and it remained at that rate for the remainder of the experiment, which covered in all a period of 10 weeks. Throughout the period the lambs were weighed individually at fortnightly intervals. The weights and other particulars are shown in Table I (p. 88).

It will be seen that the best results were obtained from the July and the worst from the August hay. Apart from the actual weights, no marked difference was observed between the three lots of lambs during the progress of the experiment. Even lot III. on the August hay seemed generally as contented as the others and the hay was as readily eaten. But although this lot made some progress at first, from about the middle of the experiment period onwards they remained practically stationary in average weight. The other two lots made continuous progress, though it was small. As is almost invariably the case with live stock, there was considerable variation, as shown in the table,

in the lambs individually. No. 28 in lot I., for example, gained 16 lb. during the experiment while C5 without any apparent cause lost 9 lb. Even in lot III., where the average gain was so much lower than in the other two lots, one lamb, No. 21, made consistent progress and made a total gain of 18 lb. Apart from what has been said, the results from Experiment I. call for little comment. Taking the figures as they are, the July hay was quite clearly the best. In the absence of digestibility tests, it is difficult to compare the actual results with the theoretical feeding value of the hay as shown by its chemical composition (p. 79). The August hay was clearly inferior in chemical composition to the June and July hay and its inferiority is confirmed by the feeding results. The most obvious advantage in chemical composition that the July hay, which yielded the best results in feeding, had over the June hay was its higher percentage of soluble carbohydrates.

Experiment II.

The second experiment was conducted during the winter of 1911-12, the hay used having been cut in June, July and August, 1911, as previously described. On this occasion, cross-bred Kerry Hill—Welsh wether lambs, purchased locally, were used. They were housed in the middle of December, and divided into three lots of 10, according to weight, on January 12, 1912, when the experiment began. It had been decided to feed the lambs this time on hay alone so as to eliminate any effect which, in Experiment I, might have been due to the oats and roots given in addition to the hay. The experiment continued over a period of ten weeks and the lambs were weighed fortnightly as before. The lambs were given as much hay as they would eat, the preliminary test having given an indication of their requirements. They were allowed 15 lb. per lot at first, but this was increased at the end of a fortnight to 20 lb., or an average of 2 lb. per head per day. and this allowance remained unaltered to the end. Drinking water was supplied in the same quantity to each lot throughout. The results are shown in Table II (p. 89).

In this experiment the best results were obtained from the June hay, though there was in fact only a small difference between it and the July hay. The August hay was again clearly the worst, the lambs fed on this (lot III) failing on the average to maintain their original weight. The individual variation among the lambs was relatively as great as in the previous experiment. Even in lot III two of the lambs gained 7 lb. and 8 lb. respectively during the period of the trial. In contrast to

this, two of the lambs on the June hay (lot I) lost weight by 8 lb. and 5 lb. respectively and one on the July hay (lot II) lost as much as 8 lb. On the other hand there were individual gains of 12 lb. in lot I and of 18 lb. in lot II. The lambs generally were smaller and less thriving than those used in the previous experiment, but were entirely free from any disease. All three lots ate the hay readily and each cleared the racks much in the same way as the others. They did not drink much water and no difference in that respect was observed between the three lots.

It is difficult here again to co-relate the results with the chemical composition of the hay, but it will be observed that the June hay, which in this instance gave the best feeding results, was the richest in soluble carbohydrates. It was, however, only slightly richer than the July hay and, similarly, the feeding results from the June hay were only slightly superior to those from the July hay. The August hay showed a poorer composition than did the other two lots and gave poorer results. Though it is recognised that the feeding value of hay is not dependent upon the soluble carbohydrates alone, it is a point of some interest that in this experiment, as in Experiment I, the variation in the soluble carbohydrates is reflected almost exactly in the results of the feeding trials.

Experiment III.

The third experiment was conducted during the winter of 1912-13. The sheep fed this time were Welsh wethers from the hill, 2½ years old and purchased for the purpose. They were housed and tagged at the beginning of December, 1912, and were allowed over a month to settle down before the experiment began. It was decided to conduct this trial on exactly the same lines as those of the previous winter and to feed the sheep on hay alone. They were arranged in three lots according to weight as before and the experiment was started on January 4, 1913. At first each lot was allowed 20 lb. of hay per day but this was increased after the first month to 25 lb., or an average of 2.5 lb. per head. Water was supplied to each lot. The results of Experiment III, which was continued over a period of ten weeks as in the previous trials, are shown in Table III (p. 90).

It will be observed that this time the sheep did not do so well as in the two previous seasons. Being older sheep and from the hill, the confinement no doubt affected them to a greater extent than it did the lambs in the two previous experiments.

Although they cleared the racks fairly regularly, lot III (August hay) being the least satisfactory in this respect, they were more restless throughout than the lambs had been. It was observed that they drank more than did the lambs and that lot II (July hay), drank most.

The best results were from the July hay, the August hay, for the third time, proving to be the worst. The results from the June hay (lot I) on this occasion were somewhat surprising and are difficult to explain. The individual variation was not so great as might be observed in other lots, but with the exception of two, all the sheep in this lot lost weight and the gain in the two exceptions was not appreciable. They ate their hay apparently as well as did lot II and there was no ailment among them, but for some reason which is difficult to determine, they failed to maintain their weight. Only in one case, however, no. 80, was the loss of weight consistent throughout. In lot III. (August hay) there was a loss of weight in all but one of the sheep and the loss was on the average at a higher rate than in lot I. This result was to some extent anticipated as the sheep did not eat their hay so readily as did the other lots. As the figures stand the general results agree with those of Experiment I, and it is to be observed that once more there was close co-ordination between the feeding results and the soluble carbohydrates in the hay, the July hay being the richest and the August hay the poorest.

Experiment IV.

As explained on a previous page, there was a gap of a year between Experiment III and Experiment IV. In the fourth experiment, the hay was harvested in 1914 and the feeding trials were conducted during the winter of 1914-15. The sheep used were again Welsh wethers purchased locally and of the same description as those in Experiment III. The wethers were housed about the middle of November and after having been in for three weeks, were arranged in three lots of ten according to weight on December 5, when the experiment began. On this occasion, pulped roots were given to the sheep in addition to the hay, and water was supplied as before. The quantity of hay allowed was 24 lb. per lot, or an average of slightly under 2½ lb. per sheep per day. An average of 15 lb. of roots per lot, or 1.5 lb. per head per day was allowed. The sheep were weighed fortnightly and the experiment extended over a period of ten weeks as before. The results are shown in Table IV (p. 91).

This time the June hay was unmistakeably the best, the August hay again for the fourth time proving the worst, but not so much worse in fact than the July hay. The sheep generally seemed more contented and did better in this experiment than in Experiment III, when hay alone was fed to them, and this may to some extent be due to the roots that were allowed in addition on this occasion. Lot I (June hay) and lot II (July hay) cleared the racks better than did lot III (August hay) and lots I and II were also observed to drink more water than lot III. There was as usual considerable individual variation among the sheep, though this was less striking than in almost any of the previous experiments. On the average, the sheep more than maintained their weight in each of the three lots, and the only individual case of serious loss of weight was that of no. 8 in lot II. Though this loss was less serious than that recorded in several instances in previous years, it was exceptional for this particular experiment and should be taken into account in considering the results from the July hay. As regards the relative value of the three lots of hay, the results of this experiment were in general agreement with those of Experiment II, the June hay being the best and the August hay the worst. This is also what might have been expected from the chemical composition of the 1914 hay, which bore a general resemblance to that of 1911. Theoretically, the July hay should have given better results than it did, but the results generally in this experiment again showed that the feeding value of the hay bore a close relation to the percentage of soluble carbohydrates. While it must be emphasised that the feeding value of hay is not determined by the carbohydrates alone, it is a matter of considerable interest that throughout the entire series of experiments here dealt with, the actual feeding results bore a consistent relationship to the percentage of soluble carbohydrates contained in the hay.

Summary and Conclusions.

The results of the four feeding trials described above are summarised in the following table :—

Average gain (+) or loss (—) in lb. per sheep during experiment.

Year.	*June hay.*	*July hay.*	*August hay.*
1910	+ 5·0	+ 7·0	+ 2·9
1911	+ 2·7	+ 2·4	— 0·1
1912	— 2·8	+ 1·5	— 4·6
1914	+ 4·0	+ 0·6	+ 0·3
Average	**+ 2·2**	**+ 2·9**	**— 0·4**

On the average of four years, the July hay yielded the best results. It has been shown, however, that in actual practice the July hay only proved its superiority in two out of the four years. In the other two the advantage lay with the June hay, though in one of those years, viz., 1911, the difference between the June and July hay was so small as to be, in experiments of this kind, practically negligible. It should also be borne in mind that the results obtained from the June hay in 1912, while they bore out what might have been expected theoretically from a comparison of the chemical composition of the June with that of the July hay, are open to some doubt owing to the behaviour of the sheep in the June hay lot. The effect of these considerations is to discount to some extent the difference which the figures show in the average feeding value of the July hay compared with the June hay over the four years covered by the experiments. In other words, the July hay, while on the average it gave considerably the best results, was probably not so much better than the June hay as the figures seem to indicate. The more correct view would appear to be that on the average of the four years, there was very little to choose as regards feeding value between the June and the July hay. The August hay, on the other hand, was definitely and clearly inferior in value, not only on the average but consistently in each of the four years, though the difference between it and the July hay in the 1914 trials was very small. The June and July hay caused, on the average, an appreciable increase in live weight and therefore had, even when used alone, a definite "production" value. The August hay was barely good enough for "maintenance."

What the results really show is that the feeding value of hay depends upon the degree of maturity the hay has reached at the time of cutting. This varies according to situation, treatment and climate and, in the same locality, varies greatly according to season. In some seasons, the hay may be as mature at a given date as in other seasons it may be three weeks or a month later, though the normal variation may not be as great as this. In accordance with this variation it might be expected that in some seasons June hay would possess a higher feeding value than any hay cut later, but in another season July hay would be quite as good if not even better. That is exactly what these experiments indicated, while showing also that hay left uncut till the middle of August were always inferior. Both the analyses and the feeding results clearly showed the disadvantage of late cutting. But while the middle of August is evidently too late to secure hay of high feeding value, no definite date can be fixed at which it may be said that hay is at its best. That is entirely a question of the

state of maturity of the hay in the particular season. It is a wise maxim, only too seldom observed, that hay should be cut when in bloom and before it begins to form seed. Under conditions similar to those that applied to the experiments described here the period of bloom in meadow hay and the best time therefore for cutting, is, according to season, between the middle of June and the middle of July. These experiments conclusively showed the superior feeding value of hay cut not later than the middle of July.

One other point brought out by the experiments may be referred to. The main object in practice in delaying hay-cutting is to secure a greater bulk of hay. The figures given on p. 78 show that while, generally speaking, it is true that hay increases in bulk as the season advances, the increase in actual weight may be after all comparatively small. As hay deteriorates in chemical composition as it gets older, once it passes the flowering stage, the increase in bulk of late-mown hay would have to be much greater than it was in these experiments before the additional bulk would be adequate to make up for the impaired quality. The feeding trials showed quite clearly that June or July hay always gave better results than did the same quantity of August hay used under exactly the same conditions. Moreover, mere bulk in hay cannot make up for deficiency in quality for the reason that there is a limit in practice to the quantity of hay that animals will eat. The sheep in these experiments did, and would, not eat any more of the August hay than they did of the June and July hay. On the other hand, it is reasonable to assume that if a certain quantity of August hay was required for a given purpose, a smaller quantity of June or July hay would have sufficed to give the same result.

It is unnecessary to emphasise the advantage of securing at all times as heavy a crop of hay as the land can be made to produce. But there is no advantage in aiming at mere bulk irrespective of quality. The aim should be to ensure not only a good crop but that the hay produced is of the highest possible feeding value. The results of these experiments amply show that the feeding value is determined by a factor that is largely within the farmer's control, viz., the time of cutting. In demonstrating that point the experiments have answered the purpose for which they were designed.

TABLE I.

EXPERIMENT I. (1910-11).

Live Weight Record.

Lot I. (June hay).

No.	Dec. 30	Jan. 13	Jan. 27	Feb. 10	Feb. 24	Mar. 10	Gain(+) or loss(—).
	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1	65	65	67	70	73	74	+ 9
4	56	55	56	57	57	57	+ 1
C5	80	74	72	73	72	71	— 9
6*m*	58	60	62	60	61	60	+ 2
9	68	67	69	67	68	71	+ 3
11*m*	63	67	68	67	69	71	+ 8
12*m*	68	71	75	76	78	81	+13
15*m*	64	63	64	63	61	60	— 4
23*m*	71	75	79	81	81	87	+16
25	53	55	58	61	64	64	+11
Average	**64·6**	**65·2**	**67·0**	**67·5**	**68·8**	**69·6**	+ **5·0**

Lot II. (July hay).

No.	Dec. 30	Jan. 13	Jan. 27	Feb. 10	Feb. 24	Mar. 10	Gain(+) or loss(—).
3*m*	68	70	74	77	78	80	+12
C4	72	71	72	71	72	73	+ 1
5*m*	70	73	75	75	76	78	+ 8
8*m*	62	65	69	68	71	72	+10
10	60	61	64	66	67	63	+ 3
16	64	65	68	71	70	69	+ 5
17	68	71	72	74	77	78	+10
19	54	57	59	62	63	67	+13
22	57	55	54	57	56	55	— 2
24*m*	72	72	76	79	82	82	+10
Average	**64·7**	**66·0**	**68·3**	**70·0**	**71·2**	**71·7**	+ **7·0**

Lot III. (August hay).

No.	Dec. 30	Jan. 13	Jan. 27	Feb. 10	Feb. 24	Mar. 10	Gain(+) or loss(—).
2	57	53	52	53	55	55	— 2
7	67	67	68	70	71	72	+ 5
13*m*	61	62	63	64	64	65	+ 4
14	69	68	70	71	73	72	+ 3
18	57	59	60	61	61	60	+ 3
20*m*	58	55	58	57	58	59	+ 1
21*m*	76	81	84	86	87	89	+13
26	66	68	71	71	71	69	+ 3
27*m*	66	69	71	67	65	64	— 2
28*m*	69	71	72	72	71	70	+ 1
Average	**64·6**	**65·3**	**67·1**	**67·2**	**67·6**	**67·5**	+ **2·9**

Note.—In the above tables, the *m* attached to the numbers in the first column indicates wether lambs.

TABLE II.

EXPERIMENT II. (1911-12).

Live Weight Record.

Lot I. (June hay).

No.	Jan. 12	Jan. 26	Feb. 9	Feb. 23	Mar. 8	Mar. 22	Gain(+) or loss(—).
	lb.	lb.	lb.	lb.	lb.	lb.	lb.
15	36	31	27	32	32	33	— 3
22	45	50	52	56	56	57	+12
23	56	56	57	55	58	57	+ 1
24	48	51	51	49	51	49	+ 1
25	56	55	57	58	59	60	+ 4
26	62	58	58	60	61	63	+ 1
34	71	66	68	67	67	66	— 5
36	56	58	59	58	57	61	+ 5
38	39	45	48	49	50	51	+12
40	63	60	63	63	61	62	— 1
Average	**53·2**	**53·0**	**54·0**	**54·7**	**55·2**	**55·9**	+ **2·7**
Lot II. (July hay).							
0	64	61	63	63	62	64	± 0
10	62	63	62	63	64	65	+ 3
11	70	67	65	67	65	68	— 2
12	46	46	46	49	46	47	+ 1
17	66	66	64	68	66	66	± 0
20	43	45	47	47	46	47	+ 4
21	35	45	50	49	49	48	+13
32	44	42	42	47	46	47	+ 3
35	48	51	54	55	56	58	+10
39	54	50	48	49	46	46	— 8
Average	**53·2**	**53·6**	**54·1**	**55·7**	**54·6**	**55·6**	+ **2·4**
Lot III. (August hay).							
2	37	33	42	41	43	45	+ 8
16	38	36	36	36	35	36	— 2
18	57	59	61	59	60	58	+ 1
19	74	78	75	74	74	74	± 0
27	46	56	58	56	53	53	+ 7
28	57	54	56	53	51	52	— 5
29	52	55	55	55	56	54	+ 2
30	47	45	44	43	43	41	— 6
33	69	73	71	71	68	70	+ 1
37	56	55	53	52	49	49	— 7
Average	**53·3**	**53·9**	**54·6**	**54·0**	**53·2**	**53·2**	— **0·1**

TABLE III.

EXPERIMENT III. (1912-13).

Live Weight Record.

Lot I. (June hay).

No.	Jan. 4	Jan. 18	Feb. 1	Feb. 15	Mar. 1	Mar. 15	Gain(+) or loss(—).
	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1	64	66	65	63	59	62	— 2
2	77	75	74	72	71	74	— 3
3	59	59	57	59	56	55	— 4
7	66	66	67	66	67	67	+ 1
16	63	63	62	55	57	59	— 4
21	61	60	57	59	57	59	— 2
22	59	56	56	56	54	56	— 3
25	62	55	57	58	56	57	— 5
29	61	59	58	63	63	62	+ 1
30	56	54	52	51	51	49	— 7
Average	**62·8**	**61·3**	**60·5**	**60·2**	**59·1**	**60·0**	— 2·8

Lot II. (July hay).

9	53	53	53	49	52	53	± 0
15	69	67	69	71	71	70	+ 1
17	56	64	65	64	63	61	+ 5
18	77	77	81	80	85	89	+12
20	52	56	57	56	56	55	+ 3
28	68	68	69	68	68	66	— 2
31	62	64	65	63	62	62	± 0
32	73	75	74	71	72	73	± 0
34	59	59	61	55	54	53	— 6
35	60	60	62	56	63	62	+ 2
Average	**62·9**	**64·3**	**65·6**	**63·3**	**64·6**	**64·4**	+ 1·5

Lot III. (August hay).

0	56	54	51	50	48	49	— 7
4	62	63	61	60	60	61	— 1
5	68	65	60	59	56	57	—11
6	53	53	52	50	49	50	— 3
14	67	67	66	66	61	64	— 3
19	60	60	59	58	57	56	— 4
23	70	67	66	66	62	62	— 8
26	67	68	63	62	63	60	— 7
27	63	61	60	63	67	65	+ 2
33	62	63	60	60	60	58	— 4
Average	**62·8**	**62·1**	**59·8**	**59·4**	**58·3**	**58·2**	— 4·6

TABLE IV.

EXPERIMENT IV. (1914-15).

Live Weight Record.

Lot I. (June hay).

No.	Dec. 5	Dec. 19	Jan. 2	Jan. 16	Jan. 30	Feb. 13	Gain(+) or loss(—).
	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1	59	57	58	60	59	59	± 0
3	75	75	80	78	76	77	+ 2
5	68	68	72	73	72	74	+ 6
13	68	70	72	72	73	74	+ 6
14	54	57	62	62	62	62	+ 8
15	71	69	71	73	73	74	+ 3
16	65	63	66	67	67	68	+ 3
17	69	68	67	67	66	69	± 0
22	67	69	71	70	69	71	+ 4
23	70	71	72	72	76	78	+ 8
Average	**66·6**	**66·5**	**69·1**	**69·4**	**69·3**	**70·6**	+ **4·0**

Lot II. (July hay).

7	66	67	67	69	67	68	+ 2
8	67	65	63	63	63	61	— 6
9	58	59	60	61	58	57	— 1
11	59	59	58	56	57	58	— 1
12	67	65	64	68	68	68	+ 1
19	71	72	71	69	69	69	— 2
24	67	69	70	72	70	70	+ 3
29	70	71	72	71	72	72	+ 2
31	69	69	71	70	70	71	+ 2
34	72	74	74	74	76	78	+ 6
Average	**66·6**	**67·0**	**67·0**	**67·3**	**67·0**	**67·2**	+ **0·6**

Lot III. (August hay).

10	67	65	64	62	64	64	— 3
18	63	63	62	61	63	64	+ 1
20	74	75	77	77	79	81	+ 7
21	53	53	51	52	50	50	— 3
27	74	73	74	75	74	74	± 0
28	68	68	67	68	67	68	± 0
30	70	70	70	69	69	70	± 0
32	65	66	69	69	68	68	+ 3
33	63	64	63	64	63	64	+ 1
35	69	65	68	65	65	66	— 3
Average	**66·6**	**66·2**	**66·0**	**66·2**	**66·2**	**66·9**	+ **0·3**

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FACTORS THAT INFLUENCE THE CHEMICAL COMPOSITION OF HAY.

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Hay is one of the most widely grown crops and forms the basis of the winter ration of the majority of live stock. The two common types of hay met with are meadow hay in which grasses predominate, and seeds hay which varies in character with the mixture sown, the bulk being generally rye grasses and clovers.

As is well known, the principal constituents of a foodstuff are fats or oils, proteins or albuminoids, carbohydrates, fibre and mineral matter or ash. Hay is characterised by its richness in carbohydrates and fibre, which together constitute 80 per cent. of its dry matter, and by its comparative poverty in fat and protein. Any factor therefore, which contributes to the increase of the protein and the decrease of the fibre, will materially improve its value as a foodstuff. A high fibre content in any foodstuff, adversely affects its digestibility, and it should be borne in mind that only the portion digested is of value for nutrition.

In the scientific feeding of animals, the aim is to supply adequate amounts of each of the necessary constituents, depending upon the animal fed, and the purpose for which the ration is designed. Owing to the preponderance of carbohydrates and fibre in hay, it does not in itself form a well balanced ration, though for maintenance, as in the case of store cattle, it supplies the animal with all its requirements. To build up a balanced

ration for production, however, hay must be supplemented with concentrated food such as linseed cake, which increases the fat and protein contents of the ration. The amount of concentrated food required depends upon the nutritive value of the hay, so that any factor that influences its chemical composition is naturally of great importance. Unfortunately, all these factors are not under the farmer's control, while those under his control, it is feared, are often not appreciated at their true value.

In this paper, the influence of the different factors is discussed, and their effects on the chemical composition of hay illustrated with examples of results obtained in mid Wales. Among the most important of these are, the stage of maturity of the hay when cut, the proportion of clovers to grasses in the hay, the leafiness of the herbage, the manurial treatment it receives and the climatic conditions under which it is harvested.

That the age of the herbage when cut has a very great influence on its chemical composition has been shown at a number of experimental stations. The marked effect of maturity on the chemical composition of pasture for example, has been demonstrated at Aberystwyth,[1] where fortnightly cuts were compared with monthly cuts. Further, as the result of work not yet published, it is very evident that there is a gradual, though constant, falling off in nutritive value of both the stem and leaf of grass with each successive week's growth.

The nature of the change that takes place is shown in Table I, which gives the chemical composition of the dry matter of Italian rye-grass at the completion of two, six and ten weeks' growth.

TABLE I.

Period of Growth in Weeks	*Ether Extract.*	*Crude Protein.*	*True Protein.*	*Fibre*	*Ash.*	*Soluble Carbohydrates*	*Silica SiO_2*	*Silica Free Ash.*	*Phosphoric Acid. P_2O_5*	*Lime CaO*	*Chlorine Cl.*	*Potash K_2O.*
2.	3.75	18.84	13.32	20.45	12.60	44.36	3.90	8.70	0.884	0.871	1.621	3.65
6.	2.42	12.12	7.80	21.62	7.95	55.89	0.93	7.02	0.449	0.910	0.889	3.17
10.	2.10	6.90	5.47	25.33	5.45	60.22	0.80	4.65	0.369	0.815	0.411	2.20

Table I shows that as grass increases in age, a considerable fall in protein occurs, accompanied by a rise in its fibre content. Also the silica-free ash in the ten weeks' growth is only about half that found in the two weeks' growth, this being reflected in all the mineral constituents determined, with the exception of lime. The growth at the end of ten weeks was ready to cut as hay,

[1] "Nutritive Value of Grasses as Pasture, Hay and Aftermath," by T. W. Fagan. *Journal of the University College of Wales*, Agricultural Department, Vol. XVI.

having just passed its state of maximum flowering. Subsequent to this, seed formation would begin, a quantity of the nutritive material being transferred from the stem and leaf to the seed. In the event of the hay being over-ripe much of this seed would be lost in harvesting, with the result that the hay would be further impoverished. This transference of nutritive material into the seed will be referred to again, when the influence of clover in hay, and more particularly the condition in which the clover is present, is considered. From what has been said, however, it will be seen that the best time to cut hay is a few days after its state of maximum flowering, and before seed formation has begun. In this connection it might be contended that to cut hay at a particular stage of growth is not difficult when made from one grass, but that when made from a mixture of grasses at varying stages of maturity it is quite impossible. In answer to this, it may be said that a safe rule to follow is to err on the side of early rather than late cutting. This will be seen from the results given in Table II which show the effect of an interval of seventeen days between the times of cutting, on the chemical composition of the dry matter of hay.

TABLE II.

Date of Cutting.	*Ether Extract.*	*Crude Protein.*	*True Protein.*	*Fibre*	*Ash.*	*Soluble Carbohydrates*	*Silica SiO₂*	*Silica Free Ash.*	*Phosphoric Acid. P2O5*	*Lime CaO*	*Chlorine Cl.*	*Potash K2O*
June 22/27	2.20	10.84	6.69	28 20	5.90	52.86	1.25	4.65	0.514	1.246	0.303	1.44
July 9/27	1.80	6.74	5.86	32.95	5.75	52.76	2.10	3.65	0.468	1.008	0.283	1.23

The above samples of seeds hay are in every way comparable, except for the difference in date of cutting. The grasses and clovers making up the hay were Italian and perennial rye-grasses, together with English late flowering and Broad Red clovers. It will be noticed that, although made from a mixture of grasses and clovers at varying stages of maturity, a delay of seventeen days in cutting the hay results in a difference in chemical composition quite as appreciable as that shown in Table I, where the hay was made from one grass. In this particular sample (Table II), the delay has resulted in a fall of 38 per cent. of crude protein with a rise of 17 per cent. in fibre, while the silica-free ash shows a fall of 22 per cent. All these changes are of a nature that detract from the quality of the hay, and lower its digestibility. It may therefore be concluded that delay in cutting hay, whether made from a single grass or from a mixture of grasses at various stages of maturity, is always

accompanied by deterioration in quality as shown by its chemical composition.

The influence of the presence of clover in hay on the composition of the crop is illustrated by a comparison of the analysis of hay made from individual grasses with that made from clover.

Table III gives the chemical composition of the dry matter of the hay of Meadow Foxtail, Italian and perennial rye-grasses, as well as that of English late flowering and Broad Red clovers.

TABLE III.

	Ether Extract.	*Crude Protein.*	*True Protein.*	*Fibre*	*Ash.*	*Soluble Carbohydrates.*	*Silica SiO₂*	*Silica Free Ash.*	*Phosphoric Acid. P₂O₅.*	*Lime CaO*
Meadow Foxtail	3.65	11.87	9.74	28.76	6.92	48.80	1.89	5.03	0.374	0.331
Italian Rye Grass ..	2.10	6.90	5.47	25.33	5.45	60.20	0.80	4.65	0.369	0.815
Perennial Rye Grass ..	1.64	7.60	6.29	31.17	4.98	54.61	0.76	4.22	0.393	0.661
English late flowering ..	3.65	19.26	16.13	27.23	10.47	39.39	1.02	9.45	0.530	2.761
English Broad Red..	3.35	22.39	17.92	22.23	9.68	42.35	0.71	8.97	0.540	3.010

The hay of Meadow Foxtail is included in the Table, because the work carried out at Aberystwyth has shown that the hay of this grass is consistently richer in protein than any other. The hay of Meadow Foxtail, however, when compared with clover hay, is seen to be poor in protein, while that of Italian and perennial rye-grasses are still poorer. As would be expected from a study of Table III, the chief effect of the inclusion of clover in hay is to increase the protein and mineral matter, particularly lime. This effect is shown in Table IV, which gives the chemical composition of the dry matter of two samples of hay in which the percentage of clovers and grasses varies.

TABLE IV.

Percentage Grass	*Percentage Clovers*	*Percentage Weeds*	*Ether Extract.*	*Crude Protein.*	*True Protein.*	*Fibre*	*Ash.*	*Soluble Carbohydrates*	*Silica SiO₂*	*Silica Free Ash.*	*Phosphoric Acid. P₂O₅*	*Lime CaO*
81.4	16.8	1.8	1.95	9.62	7.61	32.04	7.35	49.04	1.73	5.62	0.40	1.54
44.5	52.7	2.8	2.12	14.11	10.40	32.17	9.65	41.95	0.80	8.85	0.44	2.43

In the above hays, the species sown were identical, though the botanical analysis of the herbage shows a great difference in the amount of clover they contain. The increase in the proportion of clover to grass in the second hay resulted in a decided rise in the protein, ash and lime, its quality being thereby greatly improved.

The position that hay occupies as a foodstuff, makes it a matter of the highest importance that every care should be exer-

cised in its making and harvesting that the leaves and flower heads are not broken off and lost. That it is liable to considerable loss in nutritive value when this occurs will be readily appreciated on comparing the chemical composition of the stem and leaf of Timothy hay as well as that of the stem, leaf and flower head of Montgomery late flowering red clover.

TABLE V.

		Ether Extract.	*Crude Protein.*	*True Protein.*	*Fibre*	*Ash.*	*Soluble Carbo hydrates*	*Silica SiO_2*	*Silica Free Ash.*	*Phosphoric Acid. P_2O_5*	*Lime CaO*
Timothy	Stem ...	2.13	4.25	3.75	12.00	4.19	47.43	1.43	2.76	0.44	0.374
	Leaf ...	3.05	8.25	7.56	28.00	8.50	52.20	2.73	5.77	0.43	1.830
Montgomery	Stem ...	1.33	8.19	7.12	49.10	5.96	35.42	0.27	5.69	0.28	1.797
	Leaf ...	4.35	21.56	21.38	28.70	10.86	34.53	1.05	9.81	0.53	2.841
	Flower-head .	2.30	22.13	18.03	26.10	8.68	40.79	1.12	7.56	0.86	1.658

From Table V, it is seen that the fibre is particularly high in the stem compared with the leaf, while the latter is much superior in protein, ash and lime. This difference in composition between the stem and leaf is very striking in the case of clover, and shows the importance of preserving the leaf and flowerhead. From the high fibre content of the stem, and what has already been said with regard to the influence of this on digestibility, it will be seen that the more leafy the hay, the better its quality. When discussing Table I it was pointed out that seed formation is accompanied by exhaustion of the stem and leaf of certain constituents, particularly nitrogen (protein) and phosphoric acid, owing to their translocation to the seed. The effect of this on the feeding value of the stem and leaf is best seen in the case of a cereal crop such as oats. In a favourable season, when seed development is fully accomplished, the straw of such a crop is found to be poorer from a nutritive point of view than in a season when the grain has not reached the same stage of maturity, owing to the transference of material being more complete in the one case than the other. For this reason, straw cut when the crop is green is more nutritious than when the seed has fully matured. The same applies in the case of hay, for the transference of these materials to the seed takes place in a similar manner in grasses and clovers, the reproductive parts (flowerheads) as shown in Table V, being rich in these constituents.

The farmer's aim should therefore be, as already mentioned, to cut the crop before seed formation takes place and the stem becomes hard and fibrous, for by putting off the cutting later

than this, any increase in bulk is only obtained at the expense of quality.

A reason often put forward in extenuation of the fact that a hay has become over ripe before cutting, is that it contains a quantity of bottom growth. This bottom growth would be of far greater feeding value as aftermath than as a constituent of hay, the bulk of which would be over ripe and closely approaching straw in composition.

Although it seems unnecessary to point out that fields put up for hay should receive regular manuring, yet in practice cases are frequently met with where year after year, crops of hay are removed from fields to which little return is made in the form of manure. Work of an experimental nature in our country bearing on this point has been more concerned with the effect of manures on yield than on composition. That they have an effect on the chemical composition of the crop, however, cannot be doubted.

The fertilisers generally employed in Mid Wales, in addition to farmyard manure, for the purpose of manuring hay, are nitrogenous and phosphatic in character, and for this reason discussion of the effect of manures is mainly confined to these.

As far as our results indicate, and contrary to expectation, the application of nitrogenous manures does not appear to affect the ratio of leaf to stem in the crop, this being practically the same in the hay from the manured and unmanured plots. Its effect on the chemical composition of the leaf and stem, however, is very pronounced, both being affected by the manure, the yield also of leaf and stem in the treated plots is greater than the untreated.

TABLE VI

shows the chemical composition of the stem and leaf of the hay of Italian rye-grass manured with nitrate of soda, together with that unmanured.

Treatment.		*Ether Extract.*	*Crude Protein.*	*True Protein.*	*Fibre*	*Ash.*	*Soluble Carbohydrates*	*Silica SiO_2*	*Silica Free Ash.*	*Phosphoric Acid. P_2O_5*	*Lime CaO*	*Potash K_2O.*
No Nitrogen	Stem	1.50	5.47	4.16	27.52	3.45	62.06	0.50	2.95	0.40	0.392	1.78
	Leaf	2.70	8.33	6.78	23.15	7.45	58.37	1.11	6.34	0.338	1.638	2.62
Nitrogen	Stem	1.10	6.26	4.51	26.25	3.45	62.94	0.35	3.10	0.352	0.419	1.51
	Leaf	3.61	12.43	11.07	22.45	7.71	53.80	0.85	6.86	0.310	1.800	1.99

The nitrate of soda was applied at the rate of 2¼ cwt. per acre in three applications of ¾ cwt. at a time, with an interval of about three to four weeks between the applications. Table VI shows that as a result of the application of the manure, there has been an increase in the crude and true protein of both the stem

and leaf accompanied by a slight decrease in the fibre content of each. The phosphoric acid and potash, on the other hand, appear to be depressed. These results in the main confirm those previously obtained when the manure was applied to pasture, though in this case the lime was also adversely affected.[2]

The outstanding result of the addition of nitrogenous manures on the chemical composition of the stem and leaf, is the increase in the percentage of true and crude protein especially in the leaf, a result that is of still further interest when the increase in yield of both stem and leaf is also taken into consideration.

The source of phosphate generally made use of in Mid-Wales for pastures and hay is basic slag, which is particularly well suited for the large majority of the soils of the area, seeing that they are characterised by richness in organic matter and poverty in carbonate of lime. Its effect on the chemical composition of hay as seen in Table VII, appears to be confined to the mineral constituents.

TABLE VII.

	Year.	*Ether Extract.*	*Crude Protein.*	*True Protein.*	*Fibre*	*Ash.*	*Soluble Carbohydrates*	*Silica SiO_2*	*Silica Free Ash*	*Phosphoric Acid. P_2O_5*	*Lime CaO.*
Slag	1923	2.80	12.53	10.76	30.96	6.18	48.53	1.35	4.83	0.592	0.798
No Slag ..		2.61	11.79	9.36	31.25	4.22	50.13	0.99	3.23	0.410	0.544
Slag	1924	2.68	10.03	9.26	34.70	5.98	47.61	0.71	5.27	0.426	0.674
No Slag ..		2.21	9.95	8.97	33.65	4.36	49.83	0.50	3.86	0.310	0.390

Table VII shows the effect of basic slag applied in 1920 to very poor land at the rate of 200 lb. P_2O_5 per acre, on the chemical composition of the hay crops in 1928 and 1924 respectively. A comparison of the two sets of hays, that is, the hays of 1928 with those of 1924, shows the latter to be poorer in chemical composition; this is partly accounted for by the fact that the hays of 1924 were more mature, being cut about a fortnight later than in the previous year. The main difference between the manured and unmanured hays in each year is that the former are richer in silica-free ash, phosphoric acid and lime.

The land, as already mentioned, was very poor, and although as a result of the application of the slag there was an improvement in the character of the herbage, no appreciable amount of clover made its appearance, probably due to the absence of clover plants in the original sward. Had clover been present though in a suppressed state, as is the case in much of our grassland,

[2] "The influence of the application of superphosphate and nitrate of soda on the chemical composition of the stem and leaf of pasture cuts of Cocksfoot." Fagan and Evans. *The Welsh Journal of Agriculture*, Vol. II.

the slag would doubtless have encouraged its growth, and its presence in the hay would have affected its composition as already shown in Table IV. The absence of clover in the hay, however, makes the direct effect of slag on the mineral content all the more significant.

Potash is not used to any large extent in Mid-Wales either for pastures or hay, for apart from the light land round the coast, the soils are fairly well supplied with this ingredient. The following Table VIII gives the average composition of the hay from four plots receiving no manure, and from four plots to which potash was applied in the form of Sylvinit (20% K_2O) at the rate of 8 cwt. per acre.

TABLE VIII.

	Crude Protein.	*True Protein.*	*Fibre*	*Ash.*	*Soluble Carbohydrates.*	*Silica Free Ash.*	*Phosphoric Acid. P_2O_5.*	*Lime CaO*	*Chlorine Cl.*	*Potash K_2O*
No Manure ...	9.44	7.62	23.17	5.80	54.51	4.37	0.43	1.46	0.42	2.21
Potash........	9.24	8.60	29.24	6.61	52.41	5.69	0.40	1.58	0.58	2.76

It will be seen from the above Table that the application of potash has not produced a very striking effect on any of the constituents determined in the hay. This is probably due to the fact that the soil already contains an ample supply of potash. It does, however, appear to have caused some increase in the silica-free ash, lime, chlorine and potash. Although the results are typical of those obtained on the addition of potash to a variety of crops in our area, it should not be concluded from them, that there are not many pastures and hay fields in the area that would be benefited by an application of potash.

Of the manures applied to hay, farm yard manure is by far the most extensively employed in Mid Wales. Since it is a general manure, it supplies all the essential elements of plant food, though it is well known that its phosphoric acid content is generally low compared with that of nitrogen and potash.

The effect of the application of farmyard manure at the rate of 10 tons per acre on the chemical composition of hay is shown in Table IX.

TABLE IX.

	Crude Protein.	*True Protein.*	*Fibre.*	*Ash.*	*Soluble Carbohydrates.*	*Silica Free Ash.*	*Phosphoric Acid. P_2O_5.*	*Lime CaO*	*Chlorine Cl.*	*Potash K_2O*
No Manure ...	9.44	7.62	28.17	5.80	54.51	4.37	0.43	1.46	0.42	2.21
Farmyard Manure	11.70	8.76	26.70	6.63	51.25	5.16	0.42	1.48	0.53	2.03

The results shown in the above Table represent the average composition of the hay from four plots receiving no manure and from four plots to which farmyard manure was applied at the rate of 10 tons per acre. From the Table, it is seen that the main effect of the manure on the composition of the hay is to increase the crude protein and decrease the fibre. Its effect on the mineral content of the hay on the other hand, as shown by these results, appears to be negligible.

Liquid manure, also a general manure, resembles farmyard manure in being poor in phosphoric acid compared with the amount of nitrogen and potash it contains. The manurial ingredients in liquid manure, however, are present in the soluble state and for this reason are much quicker in action. The effect of the application of liquid manure on the chemical composition of hay is shown in Table X.

TABLE X.

	Crude Protein.	*True Protein.*	*Fibre*	*Ash.*	*Soluble Carbohydrates.*	*Silica Free Ash.*	*Phosphoric Acid. P_2O_5*	*Lime CaO.*	*Chlorine Cl.*	*Potash K_2O*
No Manure ...	14.50	10.53	32.10	7.82	43.78	6.21	0.68	1.05	0.59	2.06
Liquid Manure.	17.15	11.55	28.81	9.35	42.29	8.58	0.69	1.39	0.86	2.81

It should be pointed out that the high percentage of protein in both these hays is largely accounted for by the early date at which they were cut, for the luxuriant growth of the portion treated with liquid manure made it necessary to cut early.

The effect of liquid manure on the composition of hay is seen from Table X, to be similar to that of farmyard manure, in that it increases the protein and reduces the fibre content. Liquid manure, judged by these results, also increases the silica-free ash, lime, chlorine and potash, but like farmyard manure, does not affect the phosphoric acid content to any appreciable extent.

With regard to the general effect of the addition of manures to hay, it may be remarked that the difference in chemical composition as a result of their application, particularly in the case of the mineral content, is small and insignificant. However, in order that these small differences should be properly appreciated, it has to be remembered that they should be taken in conjunction with the increase in yield that almost invariably follow their application.

Hay harvested under the most favourable climatic conditions suffers a certain loss of dry matter. When harvested under unfavourable conditions, the extra turning and shaking it is

subjected to entails a further and much heavier loss through the breaking off of the finer leaves and flower heads which as already pointed out in Table V, are by far the most nutritious parts of both grasses and clovers. When, in addition, the hay is exposed to heavy rains between cutting and carting, as was the general experience in Mid Wales in 1927, the soluble nutrients are washed out of the grass, with the result that the hay becomes still poorer.

The following Table shows the effect of exposure to unfavourable weather conditions during harvest on the chemical composition of hay.

TABLE XI.

	Crude Protein.	*True Protein.*	*Fibre.*	*Ash.*	*Soluble Carbohydrates*	*Silica Free Ash*	*Phosphoric Acid. P_2O_5*	*Lime CaO*	*Chlorine Cl.*	*Potash K_2O*
No. 1	11.25	8.90	26.60	7.20	53.03	6.11	0.482	1.290	0.523	1.50
No. 2	8.05	6.91	36.65	6.14	47.65	4.30	0.500	1.100	0.205	1.[illegible]4

The two sets of analyses shown in Table XI are those of samples of hay taken at two different dates from the same field. No. 1 represents the composition of the dry matter of the hay at the date of cutting, June 22, 1927, and No. 2 that of the dry matter of the hay after it had been lying out for seventeen days during which four inches of rain fell. It will be seen that the outstanding difference between them is in fibre, No. 2 containing 10 per cent. more fibre than No. 1. In all the other constituents determined, with the exception of phosphoric acid, in which the difference between them is small, No. 1 is found to be richer than No. 2.

The hay in the interval between the two dates of sampling, that is, for seventeen days, was left untouched. If it had been turned and shaken the difference in composition would probably have been greater, for the washing out of the soluble ingredients would have been more complete. In view of what has been said of the influence of fibre on the digestibility of hay, a difference of 10 per cent. between the two hays, apart from any other, will naturally affect their nutritive value. Further, No. 2 hay will more closely resemble straw in palatability, for it will have lost the odour, colour and general characteristics associated with hay of good quality.

The effect of the various factors discussed, on the chemical composition of hay as shown by these results, may be briefly summarised as follows :—

1. The best time to cut hay is a few days after it has reached its stage of maximum flowering, and before seed forma-

tion begins. Further delay in cutting causes deterioration in quality as shown by its chemical composition.

2. The chief influence of the inclusion of clover on the chemical composition of hay is to increase the protein and mineral content, especially lime.
3. The more leafy the hay the better its quality; for this reason every care should be exercised in the making and harvesting of hay, that the leaves and flower heads (particularly in the case of clovers) are not broken off and lost.
4. Fields put up for hay should be regularly manured. The effect of nitrogenous manures is to increase the protein and decrease the fibre content. Phosphatic manures, apart from any increase in clover that may follow their application, affect the mineral content of hay, while potassic manures do not in our area appear to have any important effect on its composition—due probably to the fact that our soils are generally well supplied with potash.
5. Farmyard manure and liquid manure resemble each other in that they increase the protein and decrease the fibre content of hay. Liquid manure, in addition, increases the silica-free ash, lime, chlorine, and potash, but like farmyard manure, does not affect the phosphoric acid to any appreciable extent.
6. Hay harvested under unfavourable climatic conditions is naturally poorer than that harvested under good conditions, owing to the washing out of soluble ingredients, such hay being characterised by a high fibre content.

THE CHEMICAL COMPOSITION OF MANGOLDS GROWN IN MID WALES.

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During the last five years, a special investigation into the chemical composition of home grown foodstuffs has been in progress in the Agricultural Department, Aberystwyth.

The need for such an investigation has long been felt owing to the fact that the average figures quoted as representing the composition of home grown foods, do not necessarily represent the composition of these foods as grown in Mid-Wales.

The following paper deals with some of the results obtained with mangolds. While a great deal of our data has naturally been obtained with crops grown at the College Farm, Nantcellan, it has by no means been confined to these, for some hundreds of samples grown in the College area have also been examined.

Roots may be described as a succulent crop, that is, they contain a high percentage of water, though their value as a food depends on the dry matter they contain. The figure generally quoted and accepted for the dry matter in mangolds is 12 per cent., but from our experience of the crop grown in Mid Wales, this, as an average figure, is too high. Thus the average of some hundreds of samples of different varieties taken in the course of the last five years in this district is 8·5 per cent.

The significance of these differences in the percentage of dry matter will be more readily appreciated when it is pointed out that to supply the animal with the same weight of dry matter one must feed 141 lb. of roots containing 8·5 per cent. for every 100 lb. containing 12 per cent. of dry matter.

Very misleading conclusions are often arrived at by judging a crop such as mangolds by its yield in tons per acre, without taking into consideration the percentage of dry matter present in it. For it is possible for one crop to be several tons per acre heavier than another and yet for the lighter crop to produce a greater weight of dry matter per acre. Examples of this are by no means uncommon and one is given in the following Table.

TABLE I.

Plot.	*Manuring.*	*Yield in tons per acre.*	*Percentage of dry matter.*	*Yield in tons per acre of dry matter.*
I.	Farmyard manure and superphosphate.	39·80	11·84	4·71
II.	Sulphate of ammonia and potash.	49·05	9·74	4·77

Both plots received the same basal manuring, consisting of farmyard manure and superphosphate. Plot II, in addition, received sulphate of ammonia and potash. The variety of mangold grown in the experiment was Long Red. It will be seen that although the difference in yield per acre is approximately ten tons, yet when the dry matter is taken into consideration the difference between them is negligible.

Although one is in a better position to judge the value of a root crop when the percentage of dry matter is known, it should be noted that the chemical composition of this dry matter varies within wide limits, as shown in Table II.

TABLE II.

Variety.	Percentage of dry matter.	Percentage composition of dry matter.			
		Sugar.	Crude Protein.	True Protein.	Silica-free ash.
Yellow Globe ...	7·88	50·38	11·14	3·97	10·69
Giant Orange ...	9·20	46·84	8·98	4·03	9·99
Red Intermediate ...	9·59	38·16	10·59	3·92	10·82
Long Red ...	9·90	48·22	9·03	3·57	8·54
Golden Tankard ...	9·94	57·04	9·71	4·46	10·44

The results given in the above Table are those of a variety trial conducted at the College Farm in 1925. Table II shows that although Yellow Globe is generally amongst the lowest in dry matter, this dry matter compares more than favourably in chemical composition with that of most other varieties. Thus, apart from the sugar content of Golden Tankard, the dry matter of Yellow Globe is richer in sugar, crude protein and silica-free ash than that of any other variety.

We may conclude from this that to be in a position to judge the value of a root crop it is necessary to know, not only the percentage of dry matter in the crop, but also the composition of the dry matter. When in possession of these data, we are then in a position to calculate the yield per acre of each of the various constituents present in the crop, as shown in Table III, and this is the only safe guide to the nutritive value of the crop.

TABLE III.

Plot.	Percentage of dry matter.	Yield in tons per acre.					
		Total Yield.	Dry Matter.	Sugar.	Crude Protein.	True Protein.	Silica-free ash.
1	11·84	39·80	4·71	2·66	0·31	0·14	0·41
2	9·56	44·50	4·25	1·87	0·41	0·19	0·43
3	9·74	49·05	4·77	1·92	0·45	0·18	0·45

The results shown in the above Table have been calculated from the figures obtained in a manurial trial carried out in 1925. They serve to emphasise the fact that yield per acre is a poor

guide to the nutritive value of a mangold crop, and that in addition to knowing the yield per acre of dry matter it is of equal importance to know the composition of this dry matter.

Since the nutritive value of the mangold crop is to a large extent dependent upon the percentage of dry matter it contains, as well as the composition of this dry matter, any factor that influences these is of the greatest importance. In this connection the following experiment is suggestive, and shows the effect of early sowing on the percentage of dry matter and its composition.

TABLE IV.

Variety.	*Date of sowing.*	*Percentage of*			
		Dry Matter.	*Sugar.*	*Crude Protein.*	*True Protein.*
Yellow Globe ...	April 10.	7·88	3·97	0·877	0·312
Yellow Globe ...	April 30.	8·10	3·80	1·000	0·427
Long Red ...	April 10.	9·90	4·78	0·89	0·35
Long Red ...	April 30.	10·92	7·06	0·98	0·42
Giant Orange ...	April 10.	9·20	4·31	0·82	0·37
Giant Orange ...	April 30.	11·13	7·24	1·03	0·62
Golden Tankard ...	April 10.	9·94	5·67	0·96	0·44
Golden Tankard ...	April 30.	12·60	6·36	1·08	0·51
Red Intermediate ...	April 10.	9·59	3·66	1·01	0·38
Red Intermediate ...	April 30.	9·00	4·69	0·90	0·33

The influence of the date of sowing on the percentage of dry matter is very marked, as shown in Table IV, for with the single exception of Red Intermediate the early sown mangolds are distinctly lower in dry matter than those sown later. The lower dry matter content of the early sown mangolds has a direct analogy in their sugar content, for with the exception of Yellow Globe there is a marked decrease in this constituent in the early sown as compared with those sown later. The greatest difference is observed in Long Red and Giant Orange, the early sown showing a reduction of about 40 and 82 per cent. of sugar respectively as compared with the later sown. These results suggest that the sugar content is appreciably affected by the time of sowing and that this influence is more pronounced on some varieties than others.

Unfortunately, the yield of roots sown on the later date was not ascertained. The only difference to be seen in the field between them was that the later sown were not so uniform, being more "gappy". There was no difference in the size of roots, which might have afforded a possible explanation for the difference in composition.

Another striking point brought out by Table IV is the wide difference between the crude and true protein, and consequently the high percentage of non-protein nitrogenous substance in the crude protein, this varying from 40 to 60 per cent.

The influence of season on the dry matter content of mangolds is seen on comparing the average percentage of dry matter in the same variety grown in the three seasons, 1921, 1926 and 1927.

The following Table gives the rainfall and the hours of sunshine for each month from April to October inclusive, in 1921, 1926 and 1927, together with the average percentage of dry matter in the variety Yellow Globe in each season.

TABLE V.

	1921		*1926*		*1927*	
	Rainfall (ins.)	*Sunshine (hrs.)*	*Rainfall (ins.)*	*Sunshine (hrs.)*	*Rainfall (ins.)*	*Sunshine (hrs.)*
April.	1·50	207	1·7	186	2·07	147
May.	1·89	269	2·0	195	1·97	220
June.	0·60	242	2·2	224	5·80	117
July.	1·69	231	5·1	163	5·96	122
August.	5·67	146	4·7	169	6·25	156
September.	1·83	193	3·0	103	6·00	107
October.	2·58	124	3·4	100	3·78	114

	Percentage of dry matter (average).		
	1921	*1926*	*1927*
Yellow Globe ...	7·25	9·66	7·82

In the dry, warm weather between the time of sowing and the end of July in season 1921, little growth took place. However, at the beginning of August there was a heavy fall of rain, and during the short period between this and the time of lifting the conditions as regards moisture and warmth were favourable for rapid growth. The result of this was that the roots were

large and watery, having an average of 7·25 per cent. dry matter. In season 1927, on the other hand, the crop made a fair start, and by singling time rain had fallen and there were prospects of an excellent crop. The heavy rainfall towards the middle of June and the excessive rain of the following months caused the soil to be wet and cold; this militated against normal growth, with the result that the crop, though uniform, was light in yield and contained only 7·82 per cent. of dry matter.

Reference to Table V shows that throughout the growing period in season 1926 both the rainfall and sunshine were evenly distributed, the effect on the crop being that the yield was heavy and the dry matter high, viz., 9·66 per cent.

The effect of different manures on the composition of the Mangold.

The manurial trials conducted with the crop have been mainly confined to determining the effect of nitrogenous manures alone, and in conjunction with potash, on their yield and chemical composition.

TABLE VI.

Manuring.	*Yield in tons per acre.*	*Percentage of* Dry Matter.	*Percentage of* Sugar.	*Percentage of* Crude Protein.	*Percentage of* True Protein.
MAMMOTH LONG RED (1925).					
No nitrogen.	39·80	11·84	6·70	0·79	0·35
1½ cwt. Sulphate of Ammonia.	41·36	12·31	6·42	0·96	0·42
1 cwt. Chloride of Ammonia.	46·37	10·69	4·36	0·99	0·39
3 cwt. Sulphate of Ammonia.	39·68	11·12	4·85	1·13	0·43
YELLOW GLOBE (1926).					
No nitrogen.	40·25	8·66	4·82	1·08	0·60
1½ cwt. Sulphate of Ammonia.	39·75	7·80	4·32	1·14	0·63
1½ cwt. Chloride of Ammonia.	38·25	7·56	4·19	1·12	0·58
3 cwt. Sulphate of Ammonia.	38·25	7·86	4·24	1·18	0·60
YELLOW GLOBE (1927).					
No nitrogen.	28·46	5·74	3·10	0·63	0·40
1½ cwt. Sulphate of Ammonia.	27·63	6·70	3·75	0·59	0·31
1 cwt. Chloride of Ammonia.	28·73	5·15	3·02	0·46	0·26
1 cwt. Nitrate of Lime.	28·95	6·59	3·62	0·58	0·36

The results of the application of nitrogenous manures in seasons 1925, 1926 and 1927 are set out in Table VI. The 1927 results have been included in the Table, but the value to be attached to them is questionable, owing to the excessive rain experienced throughout the season. The plots marked "no nitrogen" received a basal dressing of farmyard manure and superphosphate (20 tons farmyard manure and 3 cwt. superphosphate per acre), the remaining plots receiving in addition the nitrogenous manures at the rates indicated.

A comparison of the total yield of crop in the three seasons shows less variation in 1927 than in 1925 and 1926; in 1925, the application of nitrogenous manures has given little increase in yield except in the case of Ammonium Chloride.

From these results (1925, 1926) it would appear that when, as in these experiments, a large dressing of farmyard manure supplemented with a phosphatic manure is applied to the mangold crop, the further addition of nitrogenous manures generally results in a reduction of the dry matter content; and further, that the percentage of dry matter is higher in mangolds receiving a moderate dressing of Sulphate of Ammonia than an equivalent amount of Ammonium Chloride.

The fluctuations in the percentage of sugar, resulting from the addition of nitrogenous manures, is less in 1926 and 1927 than in 1925, while in the first two seasons the sugar is highest in the no-nitrogen plots, and in all three seasons is lowest in the Ammonium Chloride plot. A comparison of the protein content of the different plots receiving nitrogenous manures with the no-nitrogen plot shows that, although in 1925 the increases obtained were relatively much greater than in 1926, the variation in the plots is similar in both seasons.

The results show that manures which supply nitrogen in a readily available form greatly increase the protein content of the dry matter, and that when equivalent amounts of Sulphate and Chloride of Ammonia are used there is very little difference between them.

TABLE VII.

Season.	*No Nitrogen.*	*Ammonium Sulphate (Light dressing).*	*Ammonium Chloride.*	*Ammonium Sulphate (Heavy dressing).*
1925	1 : 2·25	1 : 2·28	1 : 2·54	1 : 2·63
1926	1 : 1·80	1 : 1·81	1 : 1·94	1 : 1·93
1927	1 : 1·60	1 : 1·90	1 : 1·77	

Another effect of the nitrogenous manures is seen in the retarded ripening of the roots, as shown by the increased ratio of true to crude protein for the corresponding plots in the two seasons, 1925, 1926, Table VII.

The results show that in 1925 and 1926 a light dressing of Ammonium Sulphate had little effect on the maturity of the crop, while the Ammonium Chloride and heavy dressing of Ammonium Sulphate resulted in decidedly later maturity.

The effect of the addition of potash alone and in conjunction with nitrogenous manures on the yield and chemical composition of the crop is shown in Table VIII.

TABLE VIII.

Manuring.	*Yield in tons per acre.*	*Percentage Composition.*			
		Dry Matter	*Sugar*	*Crude Protein*	*True Protein*
MAMMOTH LONG RED (1925).					
No Potash ...	39·80	11·84	6·70	0·79	0·35
6 cwt. Kainit ...	40·65	12·10	6·56	0·80	0·39
1¼ cwt. Sulphate of Ammonia, 6 cwt. Kainit	43·00	12·53	6·45	0·91	0·43
1 cwt. Chloride of Ammonia, 6 cwt. Kainit	44·50	9·56	4·21	0·92	0·43
3 cwt. Sulphate of Ammonia, 6 cwt. Kainit	49·05	9·74	4·28	0·92	0·36
YELLOW GLOBE (1926).					
No Potash ...	40·25	8·66	4·82	1·08	0·60
1¼ cwt. Sulphate of Ammonia, 3 cwt. Sylvinite	40·25	8·53	4·77	1·14	0·68
Liquid manure ...	41·25	7·66	3·86	1·16	0·64
GIANT ORANGE (1927).					
No Potash ...	27·91	9·64	5·51	0·54	0·33
1 cwt. Potassium Chloride ...	29·05	8·45	4·69	0·64	0·44

As before, the plots marked "no potash" received the basal dressing of farmyard manure and superphosphate, the remaining plots receiving in addition potash and potash with nitrogenous manures at the rates indicated.

For the effect of potash on the yield and chemical composition of the crop, both Tables VI and VIII should be consulted. Potash alone is seen to have no appreciable effect on the yield, though when used with a nitrogenous manure in the form of Sulphate of Ammonia it has resulted in an increase. With Ammonium Chloride, on the other hand, there is a slight decrease in yield when potash is added.

When potash is used alone or with a light dressing of Sulphate of Ammonia, the dry matter shows a slight increase, but when added to the plots receiving Chloride of Ammonia or a heavy dressing of Sulphate of Ammonia respectively it has a distinctly depressing effect. The most surprising result of the addition of potash is its effect on the sugar content. For it has depressed the percentage of sugar in every case except when used in conjunction with a light dressing of Sulphate of Ammonia.

The probable explanation of this apparently negative result of potash on the sugar content is that the crop derived all the potash it required from the soil and farmyard manure. In fact, the soil is well supplied with available potash, and the farmyard manure would supply it with about 200 lb. of potash, so that the comparatively small amount supplied by the artificial would have little, if any, effect.

TABLE IX.

	No Nitrogen.	*Sulphate of Ammonia. (Light dressing).*	*Chloride of Ammonia.*	*Sulphate of Ammonia. (Heavy dressing).*
No Potash ...	1 : 2·22	1 : 2·27	1 : 2·54	1 : 2·65
Plus Potash ...	1 : 2·02	1 : 2·12	1 : 2·13	1 : 2·53

The application of liquid manure at the rate of about 2,500 gallons per acre in 1926 resulted in a marked decrease in the dry matter and sugar content, as compared with the "no potash" plot. The decrease is relatively greater in the sugar than the dry matter, the percentage of sugar being actually less than that following the dressing of Ammonium Chloride in the same season (see Table VI). Generally speaking, the addition of potash in 1925 and 1926 has resulted in a decrease in the percentage of crude protein, while it has reduced the ratio of true to crude

protein in every case, suggesting greater maturity in the case of the roots receiving potash. This effect of potash in decreasing the ratio of true to crude protein is clearly seen in the 1925 results. (See Table IX).

In 1926 the values for the light dressing of Ammonium Sulphate and Ammonium Sulphate plus Sylvinite plots were 1 : 1·81 and 1 : 1·68 respectively, the effect of potash in both seasons on the ratio of true to crude protein being similar.

The effect of Storage on the composition of Mangolds.

Mangolds grown in 1925 and stored were sampled on April 29th, 1926. On opening the clamp it was seen that the roots had made a small amount of growth. In the stored roots a similar series of determinations were made to those already carried out at lifting, and in Table X is given the percentage composition of the mangolds before and after storage.

TABLE X.

Variety.	*Percentage.*		*Percentage in dry matter.*		
	Dry Matter	*Sugar*	*Crude Protein*	*True Protein*	*Silica-free ash*
Yellow Globe (*a*) ...	8·10	3·80	12·39	5·28	9·82
,, ,, (*b*) ...	7·15	3·73	13·01	8·69	11·05
Giant Orange (*a*) ...	11·13	7·24	9·31	5·65	10·54
,, ,, (*b*) ...	9·89	7·05	10·27	7·07	12·53
Long Red (*a*) ...	10·92	7·06	9·05	3·87	9·51
,, ,, (*b*) ...	9·76	6·26	9·36	5·56	9·89
Golden Tankard (*a*) ...	12·60	6·36	8·64	4·04	9·09
,, ,, (*b*) ...	10·24	5·20	9·60	6·29	11·53
Red Intermediate (*a*) ...	9·00	4·69	10·11	3·71	11·32
,, ,, (*b*) ...	7·99	4·39	9·80	5·28	11·83

(*a*) = Before storage. (*b*) = After storage.

The Table shows that the percentage of dry matter has decreased in all the varieties during storage. This is probably largely due to the loss of dry matter by respiration and possibly partly due to moisture being absorbed subsequent to the commencement of growth in the clamp. The ratio of the dry matter before and after storage is constant in the case of four of the varieties, the exception being Golden Tankard, which has taken up relatively more water than the others, but still remains the highest in dry matter content.

The reduction in the percentage of dry matter naturally affects the percentage of sugar which in every case has fallen

during storage. In the case of Giant Orange, Yellow Globe and Red Intermediate, the reduction in sugar is not so great as that of the dry matter, while in Long Red and Golden Tankard the ratio of the percentage of sugar before and after storage is practically identical with the ratio of the fall in dry matter. During storage loss of sugar takes place through respiration, and, with sprouting, some breaking down of cane sugar into reducing sugars probably takes place.

The effect of "Bolting" on the composition of Mangolds.

A common characteristic of the mangold crop throughout Mid Wales in 1926 was the large number of roots that ran to seed. Advantage was taken of this to study its effect on the chemical composition of the mangold. Further samples were obtained in 1927, for a number "bolted" in this season also, though the percentage was much smaller than in 1926.

The following represents the average composition of the "unbolted" and "bolted" roots :—

	Unbolted.	*Bolted.*
Water	91·41	92·37
Dry matter	8·59	7·63
Sugar	4·95	3·87
Crude Protein	1·08	1·04
True Protein	0·64	0·59
Fibre	0·66	0·83
Ash	1·09	1·04
Phosphoric Acid (P_2O_5)	0·079	0·075
Lime (CaO)	0·037	0·030

Taking first the dry matter and sugar content, it is seen that "bolting" has reduced the percentage of each of these and this was found to be the case with every variety. Thus the reduction in sugar in Yellow Globe was very pronounced, whereas in Long Red it was small and relatively less than the reduction in dry matter. On the average, the reduction in the percentage of sugar amounts to about 20 per cent. of that present in the sound roots.

The dry matter of the "bolted" roots was with one exception slightly richer in all the constituents determined than that of the sound roots. The exception occurred in the protein content of one sample of Yellow Globe in which both "bolted" and "unbolted" were practically equal.

The chemical composition of the leaves of mangolds indicated that they are valuable either as a foodstuff or manure, the custom on the continent being to use them as a foodstuff. From Table XI it is seen that their dry matter compares favourably in protein with such foodstuffs as Palm Kernel Cake and Coconut Cake, while the silica-free ash content is far superior to that of any cereal or oil cake.

TABLE XI.

	Man-gold Leaves	Palm Kernel Cake	Coconut Cake	Maize	Barley
Protein (crude) ...	21·64	21·10	23·20	11·40	10·10
Silica-free ash ...	19·00	3·00		1·20	1·86
Lime (CaO) ...	2·19	0·33	0·56	0·03	0·06
Phosphoric Acid (P_2O_5)	0·98	1·22	1·65	0·63	0·84
Potash (K_2O) ...	5·61	0·57	2·24	0·38	0·56

The practice in this country is to plough the leaves in, and from the Table it is seen that the weight of manurial ingredients returned to the soil is considerable, especially of nitrogen, potash and lime, and to a smaller extent, phosphoric acid.

The results of the work carried out with mangolds as far as it has gone, may be summarised as follows :—

1. The average percentage of dry matter found in the mangolds grown in our area is considerably lower than the figure generally quoted.
2. Since the feeding value of mangolds depends upon the percentage of dry matter they contain and the chemical composition of that dry matter, yield per acre alone is not a satisfactory guide to the feeding value of the crop.
3. These results indicate that time of sowing may have an influence on the percentage of dry matter as well as upon its chemical composition.
4. The chief effect resulting from the application of nitrogenous manures was to increase the percentage of protein in the dry matter. The application of Ammonium Chloride or a heavy dressing of Sulphate of Ammonia reduced the percentage of dry matter and sugar in both seasons, while in 1926 the light Ammonium Sulphate dressing had a similar effect.
5. The effect of potash appears to be to narrow the ratio of true to crude protein, suggesting that it causes the roots to mature earlier than those receiving no potash.
6. Storage until spring has resulted in a lowered dry matter and sugar content, but the percentage of true protein in the dry matter has greatly increased. The dry matter is also richer in silica-free ash, and, with the exception of silica and chlorine, in the majority of the mineral constituents determined.
7. The effect of " bolting " has been to reduce the dry matter and sugar content of the mangold. The reduction on the average in the percentage of sugar amounts to about 29 per cent. of that originally present.

THE RELATION OF FOOD TO THE COMPOSITION OF MILK.

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and

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In dealing with the relationship between food and the chemical composition of milk there has been a tendency in the past to concentrate attention on the influence of food on the fat. The quality, yield and percentage of this constituent have been rightly considered of the greatest importance when considering milk as a marketable commodity. From the point of view of nutrition, however, some of the other constituents of milk are of equal if not greater importance. Thus the investigations which have been in progress at Aberystwyth since 1926 have shown that several of the constituents of milk other than fat are appreciably affected by food. The changes in these constituents due to food may be of special significance in comparing the relative efficiency of different methods of winter feeding advocated for dairy cows.

In the experiments of 1926 a number of shorthorn cows were divided into two groups, one group being fed on the standard ration generally advocated in this country, the other group receiving home grown cereals and maize meal instead of imported cakes in the production part of the ration. The starch equivalents of the two rations were identical, but the standard ration supplied more protein and also a greater quantity of ash constituents than the experimental ration.

The feeding of the two groups continued over a period of two months, and at the end of this time the method of feeding the groups was reversed. As a result of this experiment it was found that the average composition of milk was not affected by feeding for two months on the experimental ration. Even temporary changes that might have occurred were so small that they could not be directly detected.

The experiment was arranged in such a way that at the commencement of summer grazing the groups had been kept on their respective diets for over two months without change. An opportunity was thus afforded of finding how each group would respond to summer grazing. After a fortnight's grazing a small but significant change had taken place in the composition of the milk. Thus in both groups a rise in the nitrogen and phosphorus

content of the milk had occurred. This rise proved to be greater in the case of the milk from the group fed during the previous two months on the low protein ration.[1]

Such a finding indicated that the changes occurring in the composition of milk during the transition from winter feeding to summer grazing depend to a certain extent on the nature of the animal's winter feed. If this were always the case then a close study of these changes might ultimately provide a criterion for the efficiency of various winter rations. The results obtained in 1926 were consequently considered sufficiently important to warrant the extension of the work during the following year, and the changes in the composition of milk observed during the spring of 1927 are included in the present article.

Experimental.

During the winter of 1926-27 the cows at the College Farm, Nantcellan, were divided into two groups which were fed on two rations that differed radically one from the other in the amount of protein and ash constituents they contained. The differences between the two rations in these respects are indicated in Table I.

TABLE I.

Digestible Protein and Total Ash Ingredients supplied in Experimental Rations to Dairy Cows from January to May, 1927.

Ration A—Control Ration.
Ration B—Low Protein Ration.

	Digestible Protein. lb.		Total Lime (CaO). oz.		Total Phosphate (P_2O_5). oz.	
	Ration A.	*Ration B.*	*Ration A.*	*Ration B.*	*Ration A.*	*Ration B.*
For Maintenance	1.10	1.10	2.70	2.70	1.51	1.51
Daily production of 1 gallon	0.72	0.35	0.25	0.07	1.04	0.67
Daily production of 2 gallons	1.36	0.62	0.48	0.12	1.69	1.05
Daily production of 3 gallons	2.00	0.89	0.71	0.17	2.34	1.43
Daily production of 4 gallons	2.64	1.16	0.94	0.22	2.99	1.81

The maintenance ration, which was the same for both groups, consisted of :—

45 lb. roots.
4 lb. straw.
12 lb. hay.

The production ration, which was varied with the yield, was as follows for a three gallon cow :—

"Control" Ration.	*"Low Protein" Ration.*
1·50 lb. oats.	6·00 lb. oats.
3·00 lb. linseed cake.	3·00 lb. barley.
6·00 lb. palm kernel cake.	3·00 lb. maize meal.

[1] *Welsh Journal of Agriculture,* Vol. III, 1927, pp. 236-249.

In addition to the above, 1 lb. mash made up of equal quantities of bran and oats was added to both production rations irrespective of yield.

The animals were not periodically changed over from one ration to another as in the previous winter, so that each group had been fed for a prolonged interval on the same ration when grazing commenced in May.

In order that a larger number of samples could be dealt with in detail, the cows commenced summer grazing on three different dates, an equal number from each group being let out to grass on the same day. The milk of all the animals was sampled immediately before the beginning of grazing, and after exactly a fortnight's grazing had elapsed.

It had been found during the previous season that the nitrogen and phosphorus compounds were chiefly affected by the transition from winter to summer conditions. It was therefore decided to make a closer study of these compounds. Thus the casein was determined in addition to the total protein. The inorganic phosphorus was also estimated together with the total phosphorus.

The analytical methods employed were as follows :—

Total Protein—Determined by Kjeldahl method.
N x 6.38 = protein.

Caseinogen—Acidification of diluted milk with acetic acid.

Total Phosphate—Oxidation by means of concentrated sulphuric and nitric acid.

Inorganic Phosphate.—Removal of proteins with *trichloracetic acid*, and reduction of phospho-molybdic acid with hydroquinone. Intensity of blue colour determined with colorimeter.

Effect of Grass on the Lime and Phosphate in Milk.

The effect of grass on the lime and phosphate of the milk samples is given in Table II.

From Table II it is evident that the changes in the lime and phosphate content of the milk which occur as a result of the first fortnight's grazing in the summer depend partly on the condition of the animal at the time. Thus in the case of the two cows Polly Ddu and Nancy I there was no significant change in the lime concentration. Further, both the total phosphate and the inorganic phosphate remained constant in the milk of Polly Ddu, while no appreciable modification occurred in the inorganic phosphate of Rosie and Nancy 2.

TABLE II.

The Effect of Lush Grass on the Lime, Total Phosphate and Inorganic Phosphate of Milk.

Group A—Fed on Control Ration before grazing.

Group B—Fed on Low Protein Ration before grazing.

	% Lime (CaO).		% Total Phosphate (P_2O_5).		% Inorganic Phosphate (P_2O_5).	
	Before Grazing.	*After Grazing.*	*Before Grazing.*	*After Grazing.*	*Before Grazing.*	*After Grazing.*
EXPERIMENT I.—Cows let out to grass on 10/5/27						
Group A.						
* Polly Ddu	.1614	.1619	.2154	.2144	.1378	.1378
Seren 2	.1621	.1695	2522	.2752	.1627	.1685
Berriers 3	.1724	.1771	.2669	.2847	.1773	.1860
Group B.						
* Penwern Ann	.1822	.2060	.2281	.2578	.1411	.1547
Laura 2	.1988	.2014	.2870	.3030	.1903	.1998
Sally Lunn	.1852	.1945	.2793	.2869	1800	.1881
EXPERIMENT II.—Cows let out to grass on 13/5/27.						
Group A.						
Rosie	.1745	.1824	.2508	.2581	.1684	.1671
Jean	.1371	.1520	.2176	.2214	.1406	.1504
Group B.						
Berriers 2	.1800	.1915	.2200	.2412	.1472	.1655
Nancy 2	.1690	.1740	.2240	.2341	.1515	.1482
EXPERIMENT III.—Cows let out to grass on 17/5/27.						
Group A.						
Nancy I.	.1669	.1642	.1824	.1924	.1228	.1290
Peg	.1427	.1474	.1986	.2032	.1206	.1227
Group B.						
Nancy 3	.1703	.1824	.2170	.2312	.1340	.1420
Mabel	.1634	.1718	.2270	.2410	.1495	.1560

* Welsh Black, the other twelve cows being Shorthorn.

Apart from the above exceptions, an increased concentration of the mineral constituents resulted from grazing. Thus a decided increase in the lime and inorganic phosphate content occurred in the case of twelve animals out of fourteen, while a rise in total phosphate also occurred with thirteen cows out of the same number.

This rise in concentration is quite a remarkable phenomenon seeing that it occurred simultaneously with an increased flow of milk. It may be attributed either to an improvement in the health of the animal as a result of being left out overnight, to the much higher nutritive value of the summer grass in comparison with the winter rations, or to a specific effect of some constituents of the grass on the milk gland. That these changes in the milk

are in some way connected with the animal's food is shown by the fact that they are to a large extent dependent on the food which the animal received prior to the grazing period. The relation between these changes and the cow's winter ration is brought out in Table III.

TABLE III.

The Relationship between the Winter Rations and the Increase in Concentration of the Calcium and Phosphate of Milk which occurred after the commencement of grazing.

Group A—On Control Ration.

Group B—On Low Protein Ration.

Experiment.	Group	Increase in Percentage Lime.			Increase in Percentage Phosphate.			Increase in Percentage Inorganic Phosphate.		
		Min.	*Max.*	*Mean.*	*Min.*	*Max.*	*Mean.*	*Min.*	*Max.*	*Mean.*
1	A.	nil.	0.007	0.004	nil.	0.023	0.014	nil.	0.009	0.005
	B.	0.003	0.024	0.012	0.008	0.029	0.027	0.008	0.014	0.011
2	A.	0.008	0.015	0.011	0.004	0.007	0.006	nil.	0.010	0.004
	B.	0.005	0.012	0.008	0.010	0.021	0.016	nil.	0.018	0.007
3	A.	0.003	0.005	0.004	0.005	0.010	0.007	0.002	0.006	0.004
	B.	0.008	0.012	0.010	0.014	0.014	0.014	0.007	0.008	0.008

From the above Table it is seen that in Experiments 1 and 3 a greater increase in the lime was obtained as a result of grazing from those cows previously fed on the low protein ration. The same finding is not, however, borne out by Experiment 2, where the difference in behaviour between the two groups of animals is insignificant. With regard to the changes in the concentration of lime one is therefore not justified in coming to any definite conclusion as to the effect of the winter rations.

The position is, however, different in the case of the total and inorganic phosphate. It is seen that there is a decidedly greater increase throughout in the total and inorganic phosphate where the animals have been fed on the low protein ration. The results for the inorganic phosphate clearly bring out the fact that the rise in the total phosphate of the milk as a result of grazing is not entirely due to the very pronounced increase in the casein content to be dealt with later.

Effect of Grass on the Fat, Total Protein and Casein of Milk.

The effect of grazing on these constituents of milk is shown in Table IV.

TABLE IV.

The Effect of Lush Grass on the Fat, Total Protein and Casein of Milk.

Group A—Fed on Control Ration before grazing.
Group B—Fed on Low Protein Ration before grazing.

	% Fat		% Total Protein		% Casein.	
	Before Grazing.	*After Grazing.*	*Before Grazing*	*After Grazing*	*Before Grazing.*	*After Grazing.*
EXPERIMENT I.—Cows let out to grass on 10/5/27.						
GROUP A.						
Polly Ddu	3.90	4.23	3.19	3.39	2.42	2.50
Seren 2	3.10	3.20	3.40	3.62	2.65	2.90
Berriers 3	2.35	3.35	2.65	3.21	2.23	2.58
GROUP B.						
Penwern Ann	4.25	4.45	3.38	3.81	2.66	3.18
Laura 2	3.63	3.30	3.27	3.62	2.49	2.95
Sally Lunn	2.90	3 23	2.83	3.16	2.35	2.52
EXPERIMENT II.—Cows let out to grass on 13/5/27.						
GROUP A.						
Rosie	4.00	3.10	3.00	3.31	2.30	2.66
Jean	3.85	2.75	2.82	3.02	2.27	2.56
GROUP B.						
Berriers 2	2.95	3.23	2.86	3.19	2.29	2.62
Nancy 2	3.40	3.23	3.00	3.39	2.15	2.66
EXPERIMENT III.—Cows let out to grass on 17/5/27.						
GROUP A.						
Nancy 1	4.48	2.90	2.86	2.99	2.00	2.38
Peg	3.32	2.25	3.14	3.35	2.29	2.45
GROUP B.						
Nancy 3	3.20	2.93	2.93	3.45	2.27	2.76
Mabel	3.33	3.50	3.19	3.27	2.27	2.58

From Table IV it is seen that the changes in the fat after a fortnight's grazing were of a variable nature, but as would be expected the average percentage fat was lowered. The following are the mean fat contents of the morning and evening milk before and after grazing in the case of the fourteen cows dealt with above.

	Morning Milk.		*Evening Milk.*	
	Before Grazing.	*After Grazing.*	*Before Grazing.*	*After Grazing.*
Control group	3·30	2·99	3·52	3·23
Low Protein group	3·54	3·48	3·37	3·33

These figures show that a greater diminution in the average percentage fat took place in the milk from the control group. Although the percentage fat was diminished, a heightened production of fat resulted from both groups as a result of grazing, owing to the marked increase in the flow of milk. Thus in the control group for every 100 lb. of fat produced before grazing, 106 lb. were produced after a fortnight's grazing. In the case of

the low protein group for every 100 lb. of fat previously produced, 119 lb. were obtained after a fortnight on grass.

A fact brought out by the above fat figures is the poor quality of the evening milk from the low protein group compared with the morning milk of the same group. In this connection it is interesting to note that while the morning fat contents from January to May were practically identical for both groups, somewhat higher evening fat contents were obtained from the control group. This is shown from the following figures which summarise the fat determinations carried out on 150 samples during the period January-May, 1927.

	Morning Milk.			*Evening Milk.*		
	Max.	*Min.*	*Mean.*	*Max.*	*Min.*	*Mean.*
Control group	4·01	3·13	3·56	4·28	3·52	3·91
Low Protein group	3·76	3·18	3·53	3·91	3·33	3·70

In Table V the results for the total protein and casein are arranged so as to show how the changes in these constituents depend on the animal's winter ration.

TABLE V.

The Relationship between the Winter Rations and the Increase in Concentration of Total Protein and Casein which occurred at the commencement of grazing.

Group A—On Control Ration.
Group B—On Low Protein Ration.

Experiment.	*Group.*	*Increase in Total Protein.*			*Increase in Casein.*		
		Min.	Max.	Mean.	Min.	Max.	Mean.
1.	A.	0·20	0·56	0·33	0·08	0·35	0·23
	B.	0·33	0·43	0·37	0·17	0·52	0·38
2.	A.	0·20	0·31	0·26	0·29	0·36	0·33
	B.	0·33	0·39	0·36	0·33	0·51	0·42
3.	A.	0·13	0·21	0·17	0·16	0·38	0·27
	B.	0·08	0·52	0·30	0·31	0·49	0·40

From the above Table it is seen that a greater increase in total protein has occurred with the cows on the low protein ration. It is also clear that the increase in casein is invariably greater with the low protein group than with the control group. A further point of interest is that the increase in casein is generally more than sufficient to account for the rise in concentration of total protein. We have therefore evidence of an

increase in the phospho-protein of milk as a result of grazing, but no increase in the sum of the concentrations of the remaining proteins. In addition a rise in both the total and inorganic phosphorus has been found to occur. All these increased concentrations of phosphorus compounds took place concurrently with a marked rise in the flow of milk. This points out to the likelihood that the supply of available phosphorus in the winter rations of Mid Wales may be a limiting factor in milk production.

Summary and Conclusions.

The effect of summer grazing on the chemical composition of milk from fourteen cows has been studied. The milk was sampled immediately before grazing and a fortnight after the cows had been out on grass. The results indicate that after a fortnight's grazing there is generally an increase in the total protein, casein, total phosphorus, inorganic phosphorus and calcium concentration.

These changes in the composition of milk were found to depend on the system of winter feeding to which the cows were subjected before being let out on grass. They are therefore of special importance in that they may throw light on the relative efficiency of different winter rations advocated for dairy cows.

It is suggested that the supply of available phosphorus in the winter rations of Mid Wales may be a limiting factor in milk production.

Acknowledgment.

The writers wish gratefully to acknowledge their indebtedness to Professor Griffith and Mr. Phillips for all particulars in connection with the different rations in use at the College Farm, and for the full sampling facilities which were provided.

RATE OF GROWTH IN LAMBS.

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The importance of sheep in the system of farming in Wales is generally recognised. On the uplands the live stock consist mainly of sheep, and in recent years the number of sheep on lowland farms has increased very considerably owing largely to the desire of the farmer to economise labour and to the relatively satisfactory level of the sheep market when compared with other live stock in the post war period.

Sheep are kept nowadays mainly for the sake of the carcase. The wool, although of value, is of secondary consideration. The tendency has been to sell lambs rather than the 2-4 year old wethers. By far the greater portion of a season's crop of lambs are slaughtered before they are a year old, those that are kept are usually ewe lambs to replenish the flock of breeding ewes, ram lambs for stock purposes, and the relatively few wether lambs which are retained for the hills. The lambs are sold fat in the lowland areas usually at an age between 3-6 months, while those of the upland areas are sold as stores in early autumn to lowland farmers for autumn and winter fattening, and as a rule the bulk of these again are sold for slaughter before March.

It is recognised that the earliest milk fed fat lambs which are ready for Easter are worth considerably more per lb. live weight than similar lambs sold at a later date in the summer. The Easter lamb is a luxury, and only a few are available, whereas as the season progresses the market is glutted with fat lambs, hence the rapid drop in prices.

On the other hand, with the autumn and winter fattening of the upland wether lambs, the price per lb. live weight does not vary very much, so that the main problem is to get the stores fat in the shortest possible time.

In order to secure early fat lambs of good weights farmers generally have adapted their system of breeding and of feeding the ewes to get the best possible returns. A common breeding practice nowadays is to cross the Welsh Mountain ewes or half-bred Welsh Mountain ewes with one or other of the Down breeds and in a few instances Border Leicester and Wiltshire Horned. Which of the Down breeds is the best for crossing purposes is very difficult to establish, practically all of them have their patrons. Possibly the strain in this instance again is of more importance than the breed. A little guidance in their selection, however, is obtained from the work carried out at Bangor.[1]

The feeding of the ewes is also practised in various ways by different farmers. The main object in view is to get the ewes in good condition at lambing time and then to feed them with fresh grass, e.g., an enclosed field or meadow or first year seeds, in order to produce milk to nourish the young. In the case of the flocks under consideration, both ewes and lambs are dependent mainly upon grass. Very little hand feeding is done, as it is found difficult to get the ewes to eat hay or concentrated food,

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[1] University College of North Wales, Bangor. *Seventeenth Annual Report of the Agricultural Department*, 1906.

although they will eat roots fairly readily in the spring. At the College Farm, Nantcellan, it has been found almost impossible to get Welsh ewes to eat hay or oats or even rape and kale.

Where the aim is to secure early fat lambs, every effort is made to get the ewes to lamb early, say from the end of December to the middle of February. For the summer fat lamb trade, the end of February and March is considered sufficiently early.

This article is mainly a record of observations made in a preliminary investigation regarding the rate of growth of milk fed fat lambs.[2] The data available were largely obtained with the Pedigree Welsh Mountain Flock kept at the College Farm, Nantcellan, together with the Kerry Hill Flock of the Welsh Plant Breeding Station Farm, Frongoch.

Both flocks are solely grass fed with the exception of some mangolds in hard weather after lambing in spring, and both are kept on their respective farms thoughout the year. The main difference in the management is that whereas the Nantcellan flock is allowed plenty of " field liberty " the Frongoch flock is periodically confined within folds on the experimental grass plots. Particulars of the dates of lambing and other lambing records will be found in the appended Tables.

All the Nantcellan lambs were weighed and tattooed in consecutive numbers at birth for the two lambing seasons, 1926 and 1927, and records were made under the following headings :— Date, Weight, Dam, Sex, Singles or Twins, Type of Coat and Colour of Nostril.

The lambs were again weighed on dry days at various convenient intervals up to August in 1927, although but few later weights were obtained in 1926. For the Frongoch Flock records were obtained for 1927 only.

The particulars of the lambing records are given in Table I.

The lambing records of the Nantcellan Flock were practically the same for the two seasons, and shows that the Welsh ewes are as prolific as many of the larger English breeds of sheep. It must be realised at the outset that the Pedigree Welsh Mountain sheep kept on the lowlands attain a weight very nearly double that of the ordinary Welsh ewes found on the hills and mountains, and are much more prolific than the latter. The fertility of both flocks would be considerably higher but for the practice of allowing the ram to run with the ewe lambs so as to give them the chance of breeding and rearing as yearlings. At Nantcellan 15-20

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[2] In a future article it is proposed to furnish further particulars which are being obtained as a result of extending the recording scheme to other flocks in different parts of the College area.

TABLE I.

Lambing Records.

	1926 Nantcellan.		*1927 Nantcellan.*		*1927 Frongoch.*	
Total breeding Ewes	72		69		—	
Total lambed Ewes	69		65		47	
Total lambs dropped	94		96		55	
Total lambs reared	90		92		54	
% lambs of total Ewes in flock	130		139		117	
% Barrens	4·1		5·8		---	
% Lamb mortality	4·2		4·1		·8	
Sex Ratio.	*Ewe Lambs.*	*Ram Lambs.*	*Ewe Lambs.*	*Ram Lambs.*	*Ewe Lambs.*	*Ram Lambs.*
All lambs.						
Actual	40	54	47	49	27	19
Ratio	100	135	100	104·2	100	70·4
Singles.						
Actual	11	31	15	17	17	13
Ratio	100	272	100	113	100	76·5
Twins.						
Actual	24	24	31	29	10	6
Ratio	100	100	100	93·5	100	60

ewe lambs are retained every year and in 1926 fifteen of them reared fifteen lambs, and in 1927 the same number reared sixteen lambs. With the Welsh Flock this does not seem to have any bad effect upon the ewes, and in cases where singles are reared in the first season observations appear to show that the ewes are more likely to drop twins the following years (i.e., as two-year-olds) than if not bred from as one-year-olds. It is to be noted also that the barrens in the flock are chiefly yearlings.

The percentage lamb mortality is relatively low in all cases, and although the Frongoch figure is below 1%, the higher figure at Nantcellan in both years was due to (*a*) depredations of the fox and carrion crow; (*b*) cases of still-born. There were no instances of any lambs perishing in the severest weather, and with the Welsh lambs they invariably found their dams' teats in a few minutes after birth, and once that was secured there was not much danger of any further trouble.

The sex ratio indicates a higher percentage of ram lambs for the two seasons in the case of the Welsh Mountain sheep, and this is very pronounced in 1926. In the Kerry Flock, however, the evidence is to the contrary. Of course one is dealing with relatively small numbers in both cases. White and Roberts[3] found, in dealing with far greater numbers of lambs, that " there is no reason to suppose that the fluctuations in sex ratio in different flocks are not the result of chance ".

Rate of Lambing and Birth Weights.

At Nantcellan the earliest lambs were dropped during the last few days of January, this is by no means the earliest for Welsh sheep in the locality. It has not been possible to induce an earlier lambing time by resorting to " flushing ", probably because the ewes are always on the lowland, and are in too good a condition for any extra feeding to have any effect. Some farmers even assert that the capacity for early lambing in ewes is a question of strain. At Frongoch lambing commences about a month earlier than at Nantcellan.

Details regarding the rate of lambing and birth weights are given in Table II. For this purpose the lambing period has been divided into weekly intervals, and the figures in the Table refer to these intervals.

TABLE II.

Rates of Lambing and Average Birth Weights.

Weekly Period.	1926. Nantcellan		1927. Nantcellan		Weekly Period.	1927. Frongoch.	
	Number of Lambs.	*Average Birth Weights in lbs.*	*Number of Lambs.*	*Average Birth Weights in lbs.*		*Number of Lambs*	*Average Birth Weights in lbs.*
Jan. 30–Feb. 6 ...	4.	—	8.	6.25	Dec. 11	1.	—
Feb. 7–13	6.	7.0	5.	9.2	Jan. 1–8	4.	—
„ 14–20	11.	8.6	12.	8.4	„ 9–15	4.	—
„ 21–28	16.	7.1	11.	8.1	„ 16–22	3.	12.0
Mar. 1–7	21.	7.7	29.	8.5	„ 23–29	5.	10.0
„ 8–15	14.	8.2	12.	7.9	„ 30–Feb. 6 ..	12.	11.5
„ 16–23........	12.	7.8	3.	8.0	Feb. 7–13	2.	12.75
„ 27–Ap. 12 ...	14.	8.2	6.	8.0	„ 14–20	4.	11.5
May and July ...	—	—	4.	8.0	„ 21–28	4.	13.1
					Mar. 1–7	1.	13.0
					„ 8–15	2.	8.1
					„ 16–23	—	—
					„ 24–31	5.	10.5
					April 1–11	5.	9.4
					May–July	3.	11.0

Rate of Lambing.

(*a*) At Nantcellan lambing attains its maximum rate during the first week in March in both seasons, when about 1/3rd of 1/4th of the whole crop of lambs were dropped. This week comes practically

[3] " Fertility and Sex Ratio in Sheep ". White and Roberts. This *Journal*, Vol. III, p. 70.

in the middle of an eight-week lambing season—discounting a few "Cuckoo lambs" born in June and July. This "peak" lambing week March 1–7 corresponds to a tupping week October 1–7, but it has not been possible to correlate this peculiarity with weather conditions or any other circumstance.

(*b*) With the Kerry Flock at Frongoch lambing commences much earlier and attains its maximum rate during the week January 30–February 6, when nearly a quarter of all lambs were dropped, i.e., when lambing commences at Nantcellan. In this case the whole lambing season is extended to twelve weeks, with about the same number of lambs born before as after this particular week.

In both flocks the extension of the lambing season is to some extent due to the lambing of yearlings.

Birth Weights.

The particulars given in Table II should be considered together with various average figures in Table III.

TABLE III.

The average birth weight of lambs together with the highest and lowest individual birth weights for both sexes.

	1926 Nantcellan.		*1927 Nantcellan.*		*1927 Frongoch.*	
	Number of Lambs.	*Average birth weight.*	*Number of Lambs.*	*Average birth weight.*	*Number of Lambs.*	*Average birth weight.*
		lb.		lb.		lb.
Aver. birth weight of all lambs	90	7·8	92	8·0	47	11·0
Aver. birth weight of all ♂	51	8·2	47	8·5	16	11·3
Aver. birth weight of all ♀	35	7·2	45	7·4	18	11·0
Aver. birth weight of single ♂	31	8·9	17	8·9	13	12·5
Aver. birth weight of single ♀	11	7·7	15	8·4	17	11·7
Aver. birth weight of twin ♂	24	7·8	29	8·0	6	10·2
Aver. birth weight of twin ♀	24	7·0	31	7·1	10	10·0
Highest ♂ birth weight	Single lamb	12·5	Single lamb	11·0	Single lamb	15·25
Lowest ♂ birth weight	Single lamb	4.5	Twin lamb	4·5	Twin lamb	7·75
Highest ♀ birth weight	Single lamb	8·5	Single lamb	10·0	Single lamb	13·75
Lowest ♀ birth weight	Single lamb	4.5	Twin lamb	4·5	Twin lamb	7·5

♂ = males.
♀ = females.

Dealing first with the average figures, it is seen that the Nantcellan lambs at birth weigh 8 lb., which is equivalent to 1/15th or 6.6% of the average live weight of the ewes at 120 lb. live weight. The Frongoch lambs on the other hand weigh 11 lb. at birth, or 37.5% above the Nantcellan average, which is a considerable initial advantage in favour of the heavier breed. The average live weight of the Frongoch ewes is approximately 150 lb., so that birth weight of lamb is 7.3% of weights of the ewes.

The average birth weight of ram lambs is nearly 1 lb. above that of the ewe lambs in the Nantcellan flock, and about $\frac{1}{3}$ to $\frac{1}{2}$ lb. in the Frongoch flock. Comparing singles and twins, it is seen that the order of birth weights is as follows : single rams, single ewes, twin rams and twin ewes, showing very nearly 2 lb. difference between the extremes in all cases. Amongst individual lambs there is indeed a very wide variation in birth weights. The lowest birth weight at Nantcellan for the two seasons was $4\frac{1}{2}$ lb., which occurred in all categories, viz., singles, twins, males and females. The highest in all cases were single rams, and these roughly speaking weigh from two to three times the weight of the lowest individuals. In practically all cases the heaviest lambs were invariably dropped later than the " peak " week in the lambing seasons, but the lowest birth weights were not restricted to any particular period. Although there is such a wide variation in the sizes of lambs at birth, no lambing troubles were experienced with mature ewes, but in a few cases yearling ewes needed attention and assistance, even with lambs of less than average size.

In the weekly average birth weights (Table II) there does not seem to be any correlation between dates and weights. Unfortunately only one season's (1927) records are available for the average birth weight during the first week of the lambing season, which is well below the average for the later weeks. This figure, however, must not be taken too seriously, as the eight lambs born during the week January 30—February 6, 1927, were four pairs of twins. There is some evidence that lambs born from the middle of February to the middle of March are higher in average birth weight in all cases. The evidence to date, however, is meagre and it is hoped to secure further data this coming season.

Rate of Growth.

From the practical farmer's point of view, the rate of progress in weight during the early life of the lamb is of greater importance than birth weight. The rate of growth in lambs is

TABLE IV.

Average Rate of Growth in Lambs in Ounces per day.

NANTCELLAN, 1927.

Birth Week.	Number of Lambs.	Average Birth Weight.	Daily Gain in Ounces.	Average Weight April 7.	Daily Gain in Ounces.	Average Weight May 13.	Daily Gain in Ounces.	Average Weight May 25.*	Daily Gain in Ounces.	Average Weight June 9.	Daily Gain in Ounces.	Average Weight July 2.	Daily Gain in Ounces.	Average Weight Aug. 16.
		lbs.		lbs.		lbs.		lbs.		lbs.		lbs.		lbs.
Jan. 30–Feb. 6	8	6.25	7.7	38.0	7.0	(4) 52.0	12.7	(2) 70.0	7.4	(2) 56.0	4.2	(2) 62.0	4.0	(2) 72.0
Feb. 7–13	5	9.2	8.7	39.2	9.3	(2) 56.5	13.3	(2) 66.5	—	—	—	—	—	—
Feb. 14–20	12	8.4	9.5	37.4	10.5	(9) 59.7	10.0	(2) 60.0	8.7	(7) 76.0	4.2	(7) 81.9	3.0	(7) 89.6
Feb. 21–28	11	8.1	9.0	31.2	9.4	52.7	13.3	(2) 60.5	9.0	(7) 68.4	6.0	(7) 77.0	3.1	(6) 84.2
Mar. 1–7	29	8.5	9.4	28.4	9.9	50.6	9.3	(5) 62.6	10.4	(24) 66.1	6.5	(22) 74.3	3.6	(22) 84.3
Mar. 8–15	12	7.9	8.4	(11) 22.6	9.1	43.2	10.7	(1) 63.0	9.0	(10) 57.0	7.3	(10) 67.5	4.6	(2) 80.1
Mar. 16–23	3	8.0	10.3	19.0	10.1	41.7	12.0	(1) 54.	9.2	(2) 54.5	7.3	(2) 65.0	4.7	(2) 77.5
Mar. 25–April 3	5	7.7	—	—	10.0	34.8	—	—	10.8	53.0	8.7	65.6	5.7	81.6

* Figures in this column (Nantcellan, 1927), have reference to the best butcher's selected lambs in each group.

TABLE IV.—Continued.

FRONGOCH, 1927.

Birth Week.	*Number of Lambs.*	*Average Birth Weight.*	*Daily Gain in Ounces.*	*Average Weight Feb 1.*	*Daily Gain in Ounces.*	*Average Weight March 2.*	*Daily Gain in Ounces.*	*Average Weight May 18.*
		lbs.		*lbs.*		*lbs.*		*lbs.*
Dec. 11 (1926) .	1	—	—	58.5	8.3	74.0	—	—
Jan. 1–8	4	—	—	35.75	6.9	48.75	—	—
Jan. 9–15	3	—	—	23.0	7.0	36.0	6.1	(1) 67.0
Jan. 16–22	3	12.0	11.9	22.3	9.6	39.4	5.5	(2) 64.0
Jan. 23–29	5	10.0	11.4	15.0	7.5	29.0	6.7	(4) 61.25
Jan. 30–Feb. 6 .	12	11.5	—	—	9.6	27.1	7.4	(11) 64.5
Feb. 7–13	2	12.75	—	—	11.4	26.8	7.1	61.0
Feb. 14–20 . . .	4	11.5	—	—	12.0	20.6	7.7	57.75
Feb. 21–28	4	13.1	—	—	14.9	(3) 20.7	9.2	65.0
Mar. 1–7	1	13.0	—	—	—	—	10.0	62.0
Mar. 8–15......	2	8.1	—	—	—	—	13.3	(1) 66.0
Mar. 24–31	5	10.5	—	—	—	—	11.2	46.2
Ap. 1–11	5	9.4	—	—	—	—	10.0	36.4
May 6	3	11.0	—	—	—	—	14.0	(2) 25.0

NANTCELLAN, 1926.

Birth Week.	*Number of Lambs.*	*Average Birth Weight.*	*Daily Gain in Ounces.*	*Average Weight Feb. 18.*	*Daily Gain in Ounces.*	*Average Weight Feb. 26.*	*Daily Gain in Ounces.*	*Average Weight Mar. 30.*
Jan. 30–Feb. 6	4	—	—	16.75	9.35	21.6	11.6	(2) 48.5
Feb. 7-13	6	7.0	9.0	12.1	—	—	—	—
Feb. 14–20 ...	11	7.0	9.4	54.0 (April 29)	—	—	—	—
Feb. 21–28	13	8.0	8.3	60.0 (May 31)	—	—	—	—

dependent upon a variety of factors, the main being the milk yield of the ewes, which naturally depends very largely upon the food. Weather conditions, strain, breed or cross breed, age of ewes, undoubtedly influence the rate of progress made by individual lambs.

In dealing with progressive rate of growth in lambs it has been considered advisable to group together lambs born within a week of one another in order to deal with lambs of approximately the same live weights. As the season advances another difficulty is encountered, because some lambs within the various weekly group, which are either not required or else not sufficiently good to retain for breeding purposes, are sold to the butcher. In considering Table IV the number of lambs which figure in the averages are given in brackets alongside the live weight figures of a particular date.

Welsh lambs under conditions obtaining at Nantcellan increase in growth at an average rate of 8-10 ozs. per day for the first four months of their lives. Taking an average birth weight

of 8 lb. and a rate of growth of 9 ozs. per day, the lambs will double their birth weights in fourteen days and treble it in a month. Welsh lambs as a rule are sold to the butchers off their dams when they attain a live weight of between 60-70 lb., this figure is reached at Nantcellan when the lambs are from fourteen to sixteen weeks old.

Two other important facts are shown in Table IV. First, that the younger lambs during a given interval of time increase in weight more rapidly than the older lambs, as reading down the daily increase columns it is seen that there is a progressive increase, which although not marked in the earlier weighings becomes very pronounced in the June 9—August 16 daily increases.

Secondly, that the growth curve is fairly regular up to June 9 and then flattens out considerably, as for example in the "peak" birth week, March 1-7, the average daily increase up to June 9 is 10 ozs., then in the following month, June 9-July 2, it falls to 6.5 ozs. and up to August 16 is falls again to 3.6 ozs. per day.

It should be mentioned here that all the lambs recorded in the above table were weaned on July 29, 1927, and turned on to Clover aftermath, so that they were accustomed to this by the time of weighing on August 16. The following are some of the probable reasons for this rapid drop in rate of growth from June to August :—

1. Hot weather—both lambs and ewes lie all day in the shade and graze only in early morning and evening. It is a common experience that ewes are much easier to dry off after selling the lambs from June onwards than it is in the early part of the season April and May.
2. Dipping operations. As a preventive against maggot trouble lambs are frequently dipped at Nantcellan from June onwards. This adds to the lambs' other discomforts.
3. Various common lamb diseases and ailments together with the fact that ram lambs of the Welsh Mountain breed are apt to get bad sores round the base of the horns during the summer months.
4. Lambs which are intended for the butcher in summer are not usually shorn, so that the growing coat of wool makes the sun's heat less bearable.
5. It is evidently the same with sheep as with all other classes of farm stock, that the younger animal increases in weight more rapidly than the older.

Since both rate of growth and price per lb. diminish together very rapidly from June onwards, every effort should be made to market the lambs at this favourable time. This is borne out even more forcibly by reckoning in cash value. Thus the March 1-7 batch of lambs averaging 66.1 lb. on June 9, when lamb was 9d. per lb. live weight, were worth 49s. 6d. each, whereas the same batch kept till August 16, averaging 84.3 lb. live weight at 6d. per lb. were only worth 42s., without deducting 1 lb. per 20 lb. live weight which is the usual butchers' practice in the district where summer lambs are weighed on the farm.[4]

The demand for lambs is less in June than in August, when the inrush of summer visitors adds to the number of local consumers, hence many lambs which may have been fit for the butchers in June have to be kept on to meet this increased demand.

Similar results were obtained with the Frongoch lambs, although the daily increase is greater with the younger lambs up to March 2nd, but the fall in the growth curve occurs much earlier than at Nantcellan as shown by the March 2-May 18 daily increases. A comparison between the flocks, however, is unfair, as the Frongoch ewes and lambs were periodically (between March 2 and May 18) confined to pens on experimental grass plots.

The available data furnish another interesting fact, namely the very wide variations that exist in the rate of growth of individual lambs. In Table V are given the rate of growth of the best, medium and poorest lots in the various groups, and although the number of lambs in each sub-group is relatively small, the results are in accordance with the general experience of most farmers.

It is difficult to account for the above wide variations between the various lots of each group. The best lots in the three weekly groups increase at the rate of 13-16 ozs. per day. whereas the poorest lots gain only at about half this rate, i.e., 7-10½ ozs. daily.

The lambs in the January 30–February 6 group were all twins, and the two best lambs and the earliest sold were ewes, which is contrary to the general behaviour of the sexes as shown later. It may be argued that the lambs in the last two lots (i.e., the medium and the poorest) were kept a month longer before weighing than the best lots sold April 16, but it has already

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[4] This deduction is not made for the Easter and May lambs sold to the butcher. The practice is fairly old, *vide* Phillips' "The Soils and Systems of Farming in the Wyre Valley", 1923 (unpublished thesis).

TABLE V.

Comparison of the rate of growth in the best, medium and poorest lots.

NANTCELLAN, 1927.

Birth Week.	Number of Lambs.	Average Birth Weights	Daily gain in ounces.	Average Weight April 7.	Daily gain in ounces.	Average Weight to Butcher.	Date Sold.	Lot.
		lbs.		lbs.		lbs.		
Jan. 30	2.	6.25	8.6	41.5	13.0	49.25	April 16	Best.
Feb. 6	3.	6.3	8.1	39.7	9.8	60.5	May 11	Medium.
	4.	6.0	7.3	36.0	7.0	52	May 13	Poorest.
Feb. 7-13 ...	3.	8.2	9.5	43.0	16.0	52.0	April 16	Best.
	1.	9.5	8.3	38.0	11.3	62.0	May 11	Medium.
	2.	9.25	7.6	35.5	9.3	56.5	May 13	Poorest
Feb. 14-20 ..	1.	8.0	11.1	42	14.2	50.0	April 16	Best
	2.	10.0	10.0	40.75	12.6	67.5	May 11	Medium
	9.	8.0	9.1	36.0	10.5	59.7	May 13	Poorest

been shown that the fall in rate of growth occurs at a much later date. Similar results to the above were also obtained for the Frongoch lambs.

Single and Twin Lambs.

The fact that some breeds of sheep are more prolific than others is often favourably commented upon. It is very doubtful, however, whether this capacity for multiple births is as important as it appears, especially when one is catering for the early milk-fed fat lamb market. It is undoubtedly true that twin lambs together will scale a heavier weight than one single lamb at the end of the season in August or September.

In Table VI the records for singles and twins have been tabulated but in both cases only those lambs have been selected which have remained unsold for several weighings.

Table VI shows an appreciable difference in the rate of growth and in all cases it is in favour of the single lambs except in the " peak " week, March 1-7. This difference is more pronounced in the January 30--February 20 lambs at Nantcellan, where it is maintained throughout the season. In the other three Nantcellan lots the difference is less and becomes practically negligible as the season advances. In the Frongoch lambs the difference is very marked in all cases, no doubt due to the folding of the flock on the grass plots. This also suggests that scarcity of grass in the early part of the season may account for the big difference in the first Nantcellan lots.

Although twins in the Nantcellan lambs make a less rapid growth than singles, yet it is remarkable how slight the difference becomes with the younger lots, i.e., those dropped during the latter part of the lambing season. As grass becomes more plentiful from April onwards, the Welsh ewes are capable of

TABLE VI.

Comparison of the Rate of Growth in Singles and Twin Lambs.

NANTCELLAN, 1927.

Period of Birth		Number of Lambs	Average Birth Weight	Average Daily gain in ounces.	Average Weight April 7th.	Average Daily gain in ounces.	Average Weight May 13th.	Average Daily gain in ounces.	Average Weight June 9th.	Average Daily gain in ounces.	Average Weight July 2nd.	Average Daily gain in ounces.	Average Weight Aug. 16th.
			lbs.		lbs.		lbs.		lbs.		lbs.		lbs.
Jan. 20 to Feb. 20	Singles	4	9.4	10.5	41.0	12.0	68.0	8.6	82.5	6.0	91.0	2.0	96.5
	Twins	6	6.2	8.3	31.2	8.0	49.3	6.8	60.75	3.7	66.0	3.6	76.2
Feb. 21 to 28	Singles	2	7.25	10.0	34.0	8.8	56.5	9.2	72.0	5.9	80.5	--	--
	Twins	8	7.6	9.1	30.5	8.3	51.0	8.3	65.0	5.2	72.5	--	--
Mar. 1 to 7	Singles	8	10.0	10.5	30.75	8.8	54.5	9.2	69.0	3.0	73.2	4.0	84.5
	Twins	14	8.1	9.0	27.5	9.8	47.5	9.8	64.0	6.3	73.0	4.0	84.0
Mar. 8 to 2[illegible]	Singles	7	8.1	9.5	23.6	9.2	45.0	9.5	60.6	6.5	70.0	4.0	81.0
	Twins	6	6.75	8.7	19.75	9.0	39.3	9.3	54.5	8.2	66.3	4.8	79.7

FRONGOCH, 1927.

Period of Birth		Number of Lambs	Average Birth Weight		Average Weight Feb. 1st.	Average Daily gain in ounces.	Average Weight Mar. 2nd.	Average Daily gain in ounces.	Average Weight May 18th.
			lbs.		lbs.		lbs.		lbs.
Jan. 15–31	Singles	9	12.0		19.0	9.3	36.0	7.1	70.0
	Twins	4	10.0		14.6	7.2	27.6	5.8	55.4
Feb. 1-28	Singles	13	12.0		—	—	24.4	8.0	62.0
	Twins	2	10.0		—	—	20.2	6.9	53.0
Mar 1-31	Singles	1	13.0		—	—	—	—	62.0
	Twins	4	10.3		—	—	—	—	44.0

producing sufficient milk to nourish twin lambs quite satisfactorily. Further, the lambs soon begin to nibble grass themselves from fourteen days old onwards, with the result that should twins be getting less milk than singles they are able to make up the difference by means of fresh grass, which is particularly nutritious. Under other conditions, especially where there is a tendency to overstock with sheep, twins make a far less satisfactory progress than singles. When cold easterly winds occur in April twins are the first to suffer from the ensuing scarcity of grass.

Males and Females.

It is asserted by butchers generally that ewe lambs kill better than ram lambs, especially from July onwards. As the carcase results are left over for another article it is not proposed to deal with dead weight results at present.

It is, however, the general experience amongst farmers that butchers show a preference for ewe lambs when selecting drafts for slaughter. Whether this is an advantage or a disadvantage to the farmer depends upon circumstances, but speaking generally farmers like to be rid of as many ram lambs as possible by the end of August, except of course where ram lambs are retained for breeding purposes. A comparison is made of the rate of growth in male and female lambs in Table VII.

The figures in Table VII for Nantcellan illustrate the fact that single ram lambs increase in growth at 1-2 ozs. per day more than any of the other groups during the first four months of their lives. They therefore reach the end of the period of high rate growth earlier than the others, consequently the drop in the rate of growth in their case is more marked than in the case of any of the other lots after this point in the growth curve has been reached.

Twin ram lambs also gain remarkably rapidly considering that they have to put up with competition for the dam's milk, but they either secure more of it or else make better use of it than their competitors, as their rate of growth is not much below that of the single rams.

Ewe lambs never seem to be able to make up for their disadvantage in birth weight. Single ewe lambs make better progress at first than twin ewe lambs, but towards the end of the season, especially in the case of those born after March 1, twin ewe lambs eventually attain the same weight as single ewe lambs, which is over 10 lb. less than the average for rams by August 16. The figures tend to indicate the advantage of selling ram lambs in the early part of the season for several reasons.

TABLE VII.

A Comparison of the Rate of Growth in Males and Females in Singles and Twins.

NANTCELLAN, 1927.

Birth Period.	Singles or Twins.	Sex.	Number of Lambs.	Average Birth Weight in lbs.	Average Weight April 7.	Daily Gain in Ounces.	Average Weight May 13.	Daily Gain in Ounces.	Average Weight June 9.	Daily Gain in Ounces.	Average Weight July 2.	Daily Gain in Ounces.	Average Weight August 16.
Jan. 30–Feb. 20	Singles	M	3	9.8	44.0	13.0	73.0	8.9	88.0	6.3	97.0	1.8	102.0
		F.	1	8.0	33.0	9.0	53.0	7.7	66.0	5.6	74.0	2.1	80.0
	Twins	M.	0	—	—	—	—	—	—	—	—	—	—
		F.	6	8.3	31.2	8.0	49.3	6.8	60.75	3.6	66.0	3.6	76.25
Feb. 21–28.	Singles	M.	1	8.0	40.0	10.7	64.0	10.0	81.0	7.0	91.0	1.0	94.0
		F.	1	8.5	28.0	9.3	49.0	8.3	63.0	5.0	70.0	—	—
	Twins	M.	4	8.0	31.25	9.4	52.5	9.5	(1) 70.0	7.0	(1) 80.0	—	—
		F.	4	7.4	30.0	8.2	48.5	7.7	(1) 60.0	3.5	(1) 65.0	—	—
March 1–7.	Singles	M.	4	9.4	32.0	11.2	57.25	9.6	73.5	2.0	(2) 76.0	4.6	(2) 89.0
		F.	4	8.0	27.5	10.8	51.75	7.6	64.5	4.5	(3) 71.0	2.8	(3) 79.0
	Twins	M.	9	8.0	27.1	9.3	48.1	10.3	65.5	6.7	75.1	3.7	85.7
		F.	5	7.7	25.4	9.3	46.4	8.6	61.0	6.3	70.0	4.0	81.0
March 8–23.	Singles	M.	2	9.0	28.0	11.4	53.5	11.6	73.0	7.0	83.0	3.5	93.0
		F.	5	7.8	22.0	8.7	41.6	8.3	55.6	6.0	64.2	4.2	76.0
	Twins	M.	3	7.0	20.7	9.4	42.0	9.3	57.7	7.7	68.7	4.6	81.7
		F.	3	6.3	18.7	8.0	36.7	8.7	51.3	8.9	64.0	4.9	77.7

TABLE VII.—Continued.

FRONGOCH. 1927.

Birth Period.	Singles or Twins.	Sex.	Number of Lambs.	Average Birth Weight.	Average Weight Feb 1.	Daily Gain in Ounces.	Average Weight Mar. 2.	Daily Gain in Ounces.	Average Weight May 18.
				lbs.	lbs.		lbs.		lbs.
Jan. 15–31.	Singles	M.	4	12.0	18.4	9.7	36.0	7.5	72.0
		F.	5	11.9	(3) 19.9	8.9	(5) 36.0	6.6	(3) 68.0
	Twins	M.	3	11.0	(1) 17.5	7.0	(3) 30.2	7.2	65.0
		F.	3	9.0	13.7	6.2	24.9	4.4	46.0
Feb. 1–28.	Singles	M.	4	14.0	—	—	22.0	9.0	65.0
		F.	9	11.5	—	—	26.0	7.4	61.75
	Twins	M.	1	10.5	—	—	21.25	7.2	56.0
		F.	1	9.5	—	—	19.25	6.4	50.0

(*a*) They attain heavier weights when prices are high.

(*b*) Their rate of growth towards the end of the season is less than that of ewe lambs.

(*c*) It is much easier to sell any surplus ewe lambs at a fair figure at the end of the season than is usually the case with ram lambs.

Pedigree Ram Lambs for Breeding Purposes.

Breeding pedigree rams and ram lambs has been much encouraged during recent years, and with many breeders this has become a successful side line. Whether this can be recommended or not depends upon circumstances :—

(*a*) The supply and demand.

(*b*) The standard of excellence in breed points.

(*c*) The price secured.

(*d*) The reputation of the strain or breed.

In cases where good prices are secured for the pedigree ram lambs this breeding practice is a source of profit, but where the cash value of the ram lambs in the autumn is on the verge of butchers' prices it is very doubtful whether the practice is at all advisable. It is, however, extremely difficult to know at an early age what a particular individual lamb will develop into. A common experience amongst breeders is to find that in many instances a most promising youngster fails in the long run to fulfil expectations. In the following Table VIII data are provided of the live weights and approximate butchers' prices for a number of Pedigree Welsh Mountain ram lambs bred at Nantcellan.

These figures once more show very clearly the importance of knowing the fat lamb market together with the live weights of lambs on hand at different times in the season. The ram lambs at Nantcellan born February 18–March 8 attain their best butchers' value early in May, whilst those born in Mid-March are of maximum butchers' value in early June. It is probably correct to state that many farmers would have mistakenly decided to retain similar lambs to become heavier weights at a later date in July. In deciding whether pedigree ram lambs should be kept for the breeding market or not it is evident that, apart from quality, the guiding factor should be the highest value (i.e., butchers' prices) the particular lamb has reached during the season. Thus five of the heaviest Nantcellan lambs were worth on an average 68s. in early May. This figure plus the cost of keeping for nearly another five months must be the basis of calculation. Fixing an approximate figure of 20s. for

TABLE VIII.

Live Weights and the approximate Butchers' Prices of Pedigree Welsh Mountain Ram Lambs.

NANTCELLAN 1927.

Date of Birth.	Birth Weight in lbs.	Weight April 7	Value at 1/- per lb. live weight.	Weight May 13	Value at 1/- per lb. live weight.	Weight June 9	Value at 9d. per lb. live weight.	Weight July 2	Value at 7d. per lb. live weight.	Weight Aug. 16	Value at 6d. per lb. live weight.	Weight Sept. 13	Value at 6d. per lb. live weight.
		lbs.		lbs.		lbs.		lbs.		lbs.		lbs.	
February 18	11	48	48/-	79	79/-	97	73/6	107	65/6	111	55/6	112	56/-
„ 18	10	43	43/-	73	73/-	82	61/6	89	52/-	93	46/6	92	46/-
„ 20	8	40	40/-	64	64/-	81	60/9	91	53/-	94	47/-	98	49/-
„ 21	8	31	—	54	54/-	70	52/6	80	46/8	—	—	—	—
„ 28	8½	28	—	52	52/-	66	49/6	73	42/6	86	43/-	84	42/-
March 3	8½	29	—	62	62/-	78	58/6	87	50/9	97	48/6	97	48/6
3	10	38	—	60	60/-	76	57/-	—	—	81	40/6	94	47/-
„ 3	11	37	—	64	64/-	82	61/6	—	—	100	50/-	121	60/6
„ 7	{ 9	28	—	48	48/-	68	51/-	79	45/-	90	45/-	93	46/6
	8	27	—	52	52/-	69	51/9	80	46/8	92	46/-	98	49/-
„ 12	{ 8	22	—	43	—	57	42/9	67	39/-	80	40/-	77	38/6
	7½	22	—	44	—	60	45/-	70	41/-	81	40/6	81	40/6
„ 12	6	18	—	39	—	56	42/-	69	40/3	83	41/6	84	42/-

No deduction of one lb. for every 20 lbs. live weight has been made in calculating the approximate values. Taking this into consideration, the actual value of the various lambs would be 2/- to 2/6 less than the above figures from July onwards.

the cost of keeping without charging for the labour and expense in dipping and shepherding, it is seen that such lambs should be worth at least 4½ guineas for breeding purposes.

Breeding from Yearling Ewes.

A certain amount of data have been collected concerning the merits of the practice of early breeding in sheep under favourable conditions. As already stated the practice at Nantcellan has been to retain a number of ewe lambs to make up the wastage in the flock through drafting off. The rams have been allowed to run with them, and as a rule only two or three out of fifteen to twenty have failed to rear a lamb during the following season.

Table IX shows the average rate of growth in the case of the Nantcellan lambs reared by yearling and mature ewes by the same ram.

From the above Table it is seen that at Nantcellan yearling ewes do not couple to anything like the same extent as 2-3 year-old ewes, which in the above instances had produced lambs as yearlings. This is a common experience with lowland farmers with a flock of Welsh ewes.

The range in birth weights in the case of lambs from the yearling ewes varied from 4½ lb. (a twin ewe) to 9 lb., whilst in the other group from 5½ lb. (a twin ram) to 9 lb., the average birth weight being slightly in favour of the lambs from the mature ewes.

Yearling ewes are usually the last to drop their lambs, and in the above cases their lambs are on an average ten days younger than the others. These, however, make a fairly rapid progress, their rate of growth being only slightly less than those multi-twinned lot up to June 9, whilst after this date the order of daily increase is reversed, so that by August 16 the actual difference in average live weight is 3.7 lb.

Allowing a similar daily increase for another ten days so as to make the ages equal, it is seen that the difference between the two lots becomes negligible from June onwards, as the heaviest individual lambs in both the July 2 and August 16 weighings was from the younger lot 86 lb. and 99 lb. respectively, whereas the heaviest weight in the other lot for these two weighings was 83 lb. and 97 lb. respectively.

It must be emphasised again that the twin factor has a considerable influence on rate of growth, but owing to the size of the flock it has not been possible to get a better comparison of the capabilities of the two lots of ewes as lamb rearers. It does appear, however, that under favourable conditions of pasturage

TABLE IX.

Comparison of the rate of growth in lambs from yearling and mature ewes.

DAMS.	*Birth Period.*	*Average Date of Birth.*	*Number of Lambs.*	*Average Birth Weight.*	*Daily Gain in Ounces.*	*Weight April 7th.*	*Daily Gain in Ounces.*	*Weight May 13th.*	*Daily Gain in Ounces.*	*Weight June 9th.*	*Daily Gain in Ounces.*	*Weight July 2nd.*	*Daily Gain in Ounces.*	*Weight Aug. 16th.*	REMARKS.
				lbs.		lbs		lbs.		lbs.		lbs.		lbs.	
Yearling Ewes..	Mar. 3rd to April 2nd	Mar. 17th	11	7.6	10.5	21.4	8.8	41.2	8.8	56.	8.0	67.3	5.0	81.3	5 Females, 6 males, 1 pair of Twins.
Two and Three Old Ewes	Mar. 4–10	Mar. 6th	14	8.0	9.1	26.3	9.5	47.6	9.4	63.4	7.4	74.0	4.0	85.0	7 Females, 7 Males, 6 Pairs of Twins.

and management the practice of mating Welsh ewe lambs is thoroughly sound, both as a breeding scheme and as a financial proposition.

Summary.

1. The present account is a preliminary report of an investigation concerning the rate of growth in lambs.
2. Low or high birth weights is no criterion of the rate of growth in lambs.
3. Factors influencing the rate of growth have been noted, viz., Sex, Singles or Twins, Individuality and Age.
4. In the flocks under consideration lambs increase in weight at the average rate of 8-10 ozs. per day for the first four months, but from this date onwards the rate of growth decreases rapidly.
5. February and March born lambs approach their maximum weights in August, and their best butchers' value in May and June.
6. Under favourable conditions the practice of breeding from Welsh ewe lambs can be recommended.

Acknowledgment.

I beg to acknowledge my indebtedness to Mr. M. G. Jones, M.Sc., for supplying the weights, etc., of the Frongoch lambs, and to Mr. T. J. Jenkin, M.Sc., for his helpful criticism. Finally, my cordial thanks are due to Professor J. J. Griffith, B.Sc., for his advice and guidance.

STUDIES ON COLOSTRUM.

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This investigation into the composition of colostrum was undertaken as the result of work on the chemical composition of milk which has been in progress at Aberystwyth since January, 1926. The main object of the investigation was to determine whether age and breed had any influence on the composition of colostrum.

Owing to the difficulty of obtaining samples of the first milking for analysis, samples of the second and third milkings drawn at intervals of twelve and twenty-four hours after calving were made use of. Important fluctuations in the ash ingredients of normal milk were met with in the work already referred to,

and consequently a detailed examination of the ash of colostrum was undertaken.

The variable nature of Colostrum.

The outstanding feature of colostrum is the wide variations found in the composition of samples taken from individual cows. The maximum and minimum values for each constituent determined in fifty-six samples of colostrum in the course of this investigation are given in Table I. For comparison the maximum and minimum values found in normal milk from individual cows of the same herds are also given.

TABLE I.

Variations in the composition of colostrum and normal milk.

	COLOSTRUM. Second Milking.		COLOSTRUM. Third Milking.		NORMAL MILK.	
	Maximum.	*Minimum*	*Maximum*	*Minimum*	*Maximum*	*Minimum.*
Total Solids	29.81	13.77	21.86	13.74	15.33	10.01
Fat	6.75	0.80	7.15	0.65	8.95	1.70
Solids not Fat	23.96	10.58	18.13	8.99	10.07	7.61
Protein	18.45	5.07	13.40	4.52	4.23	2.55
Ash	1.163	0.804	1.060	0.758	0.833	0.610
Lime (CaO)	0.3142	0.1516	0.2700	0.1370	0.2425	0.1162
Phosphoric Acid(P_2O_5)	0.4502	0.2695	0.4188	0.2350	0.2844	0.1483
Potash (K_2O)	0.2537	0.1161	0.2485	0.1358	0.2469	0.1080
Chloride (Cl)	0.1666	0.0962	0.1543	0.0829	0.1683	0.0460

The variations given in Table I show that the total solids, fat, solids-not-fat and protein vary within wider limits in colostrum than in normal milk. The ash ingredients on the other hand show somewhat larger variations in normal milk, the variation in the chloride content of milk being markedly greater than that in colostrum.

The constituent found to be subject to the widest variation in colostrum is fat. This varies in the second milking from 0.80% to approximately nine times this amount. The protein also is subject to wider variations than the other ingredients, the ratio between the maximum and minimum values for both milkings being in the neighbourhood of 3 : 1 as compared with 2 : 1 for the other constituents.

The difference in compositoin between Colostrum and normal Milk.

Table II gives the mean values for each constituent in the second and third milkings of the colostrum of the shorthorn cows included in this investigation. These are compared with the average composition of 185 samples of normal milk from cows of the same herd taken within the same period.

TABLE II.

The average composition of colostrum compared with that of normal milk.

	Colostrum. Second Milking. %	*Colostrum.* Third. Milking. %	*Normal Milk.* %
Total Solids ...	20·65	16·68	12·63
Fat ...	3·31	3·50	3·69
Solids-not-fat ...	18·26	13·18	8·94
Protein ...	13·05	8·15	3·41
Ash ...	0·937	0·817	0·708
Lime (CaO) ...	0·2011	0·1864	0·1646
Phosphoric Acid (P_2O_5)	0·3390	0·3269	0·2324
Potash (K_2O) ...	0·1902	0·2005	0·1952
Chloride (Cl) ...	0·1323	0·1135	0·0962
P_2O_5/CaO ...	1·68	1·74	1·41

Table II clearly shows that colostrum as represented by both the second and third milkings is much richer than normal milk. The constituent present in largest amount in both colostrum samples is protein, which is far in excess of that found in milk. The high percentages of protein in these colostrum samples largely account for the amounts of total solids present.

From the above Table we see that the ash content of colostrum is high, the phosphoric acid being markedly higher than in normal milk, as is also the lime, the ratio of phosphoric acid to lime being distinctly higher in colostrum than in milk.

It has been previously indicated that the third milking of colostrum was taken at a period of twelve hours after the second milking. Even in this short interval a profound modification has occurred in the concentration of some of the ingredients. As a consequence the third milking is poorer than the second but is still much richer than normal milk.

In order to study the behaviour of each constituent during the first few days after calving, four samples from different milkings of the same cow were taken. The amounts of the ingredients present in these different samples are given in Table III. For comparison the average composition of the milk of the same cow over the first six months of its lactation is also given.

We can regard colostrum as a fluid containing a surplus amount of the nutrients normally present in milk, while also containing other products not found when the milk gland is in normal condition. We have a much greater surplus of some constituents than others in the first milkings, a notable excess of protein, chloride, phosphoric acid and lime being present at this

TABLE III.

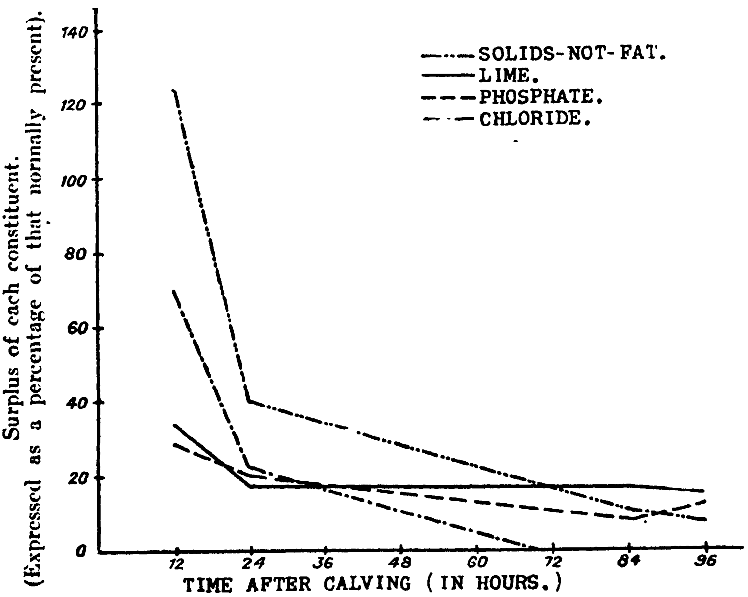
The composition of colostrum from the same cow at different intervals after calving.

INTERVAL AFTER CALVING.	*Fat.* %	*Solids—not fat.* %	*Ash.* %	*Lime (CaO).* %	*Potash (K_2O).* %	*Phosphoric Acid. (P_2O_5).* %	*Chlorine (Cl).* %
12 hours	4.80	20.07	0.996	0.2230	0.1835	0.3111	0.1526
24 hours	3.20	12.54	0.915	0.1997	0.2200	0.3000	0.1101
84 hours	4.40	9.95	0.804	0.1998	0.1959	0.2743	0.0866
96 hours	3.70	9.49	0.783	0.1929	0.2034	0.2761	0.0969
Average composition of the Normal Milk	3.64	8.91	0.756	0.1686	0.1989	0.2485	0.0898

time. The large excesses of protein (as reflected by the solids-not-fat) and chloride are probably due to abnormalities in the milk gland and have no great significance in so far as the growth of the calf is concerned. The excess of these two ingredients disappears very rapidly during the first two days.

FIG. 1.

The rate of disappearance of the surplus of each constituent with time.



The surplus of lime and phosphoric acid on the other hand is probably connected with the needs of the growing calf and does not disappear as rapidly as does the surplus of the protein and chloride. While only a small fraction of the extra protein and chloride remains in the colostrum taken four days after calving there still remains a large fraction of the surplus lime and phosphoric acid at the end of this period.

These considerations are clearly brought out in Fig. I. Here the surplus of each constituent is expressed as a percentage of the quantity normally present in milk and the rate at which the surplus disappears with time is shown. The rapid diminution in the solids-not-fat (due to decrease in protein) and in chloride stands out in marked contrast with the comparatively gradual changes in the surplus lime and phosphoric acid.

The influence of age.

Seeing that the yield and composition of milk are influenced by the age of the animal it was considered desirable to find what effect, if any, the age factor had on the composition of colostrum. For this purpose the results of those samples from animals approximately the same age have been averaged and these are given in Table IV. To eliminate variations which might be due to breed, only shorthorn cows are considered.

TABLE IV.

The influence of age on the colostrum of Shorthorn cows. (Mean of second and third milkings).

LACTATION PERIOD.	*Fat.* %	*Solids—not fat.* %	*Protein* %	*Ash* %	*Lime* (*CaO*) %	*Potash* (K_2O). %	*Phosphoric Acid.* (P_2O_5). %	*Chlorine* (*Cl*). %
1st	4.19	18.11	12.20	0.855	0.1676	0.1822	0.3200	0.1244
2nd and 3rd	3.85	12.46	6.87	0.871	0.1875	0.2160	0.3213	0.1162
4th and 5th.....	3.13	16.52	13.97	0.925	0.2078	0.1830	0.3597	0.1264
6th and over ...	2.10	16.66	13.86	0.909	0.2150	0.2010	0.3270	0.1254

From Table IV we see that the fat content of colostrum decreases with age. The percentage of solids-not-fat while high after the first calf is at a low level after the second and third calves. For later calves it increases to a constant value. These remarks also apply to the amount of protein present.

The percentage of ash present reaches a maximum in the colostrum after the fourth and fifth calf. This is also true of the phosphoric acid, and it is seen that all fluctuations in this ingredient closely resemble those of the ash. The lime content rises with successive calves, while the chloride remains almost constant. The potash shows no regular variations.

The Influence of Breed.

In order to study the effect of breed on the composition of colostrum, samples were taken from different breeds found in the College area. Owing to the limited number of herds other than shorthorn it was not possible to make an extensive study of the colostrum from all breeds. A sufficient number of samples was obtained, however, to show the main differences that can

be attributed to breed. A comparison of the results from the four breeds found in the district is given in Table V.

TABLE V.

The composition of the colostrum of four breeds of cattle. (Mean of second and third milking).

BREED.	*Fat.* %	*Solids—not fat.* %	*Protein.* %	*Ash.* %	*Lime* (CaO). %	*Potash* (K_2O). %	*Phosphoric Ash.* (P_2O_5). %	*Chlorine* (Cl). %
Shorthorn	3.41	15.72	10.60	0.877	0.1938	0.1954	0.3329	0.1229
Welsh Black	3.54	11.87	6.62	0.878	0.1849	0.1937	0.3239	0.1247
Ayrshire	3.27	14.32	9.00	0.934	0.1745	0.1831	0.3178	0.1422
Jersey	1.85	15.16	8.17	1.072	0.2584	0.1913	0.4206	—

An interesting point that is brought out by the results in Table V is that the colostrum of the Welsh Black is poorer in solids-not-fat than that of other breeds. This is due to the low protein content of the Welsh Black colostrum. An outstanding feature of the colostrum of the Jersey is that while the protein is comparatively low the solids-not-fat are relatively high. This indicates that the colostrum of the Jersey as compared with other breeds contains a greater proportion of sugars or other undetermined constituents. The colostrum of the Jersey is also exceptional in that it contains much greater amounts of lime and phosphoric acid than other breeds.

Summary.

Samples of colostrum taken from four breeds found in Central Wales have been examined. It has been found that :—

(*a*) The composition of colostrum varies within wide limits, the constituents subject to widest variation being fat and protein.

(*b*) Colostrum is much richer than normal milk. The constituent present in largest amount in colostrum compared with that normally present in milk is protein. The ash content is also high, the phosphoric acid being markedly greater than in ordinary milk.

(*c*) The surplus of protein and chloride disappears rapidly during the first few milkings. The excess of lime and phosphoric acid, on the other hand, which is probably connected with the needs of the growing calf, does not disappear as rapidly as the surplus of protein and chloride.

(*d*) The fat content of colostrum decreases with age. The percentages of solids-not-fat and protein while high after the first calf are at a low level after the second and third calf and increase to a constant level for later calves. The

percentages of ash and phosphoric acid present reach a maximum after the fourth and fifth calf. The lime rises with successive calves.

(*e*) The colostrum of the Welsh Black is poorer in solids-not-fat and protein than that of other breeds. The colostrum of the Jersey is exceptionally rich in lime and phosphoric acid.

Acknowledgements.

I would like to acknowledge my indebtedness to those who have granted facilities for the collection of samples and to Mr. R. O. Davies, M.Sc., for suggesting the investigation and for his guidance during the course of the work.

STUDIES ON THE BACTERIOLOGICAL CONTENT AND KEEPING QUALITY OF MILK.

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I. Introduction.

Nine Clean Milk competitions have been organised in Mid and West Wales during the last three years. The present paper is a review of the statistics concerning the results of the bacteriological examinations, and of the keeping qualities of the samples. An attempt has been made to show the relationship between the bacterial content of the milk and the resulting keeping qualities. The influence of various basic factors, such as seasonal temperature, and technique of production are also treated.

For the purpose of this study, figures obtained from the following competitions and surveys have been tabulated :—

	Duration.	*Number of competitors.*
1. Brecon and Radnor, 1925 ...	Jan.–March.	11
2. Brecon and Radnor, 1926 ...	Feb.–June.	10
3. Carmarthenshire, 1926 ...	Feb.–April.	13
4. Carmarthenshire, 1927 ...	March–July.	9
5. Cardiganshire, 1927 ...	Feb.–July.	24
6. Montgomeryshire, 1926 ...	Jan.–April.	10
7. Montgomeryshire, 1927 ...	Feb.–August.	13
8. Pembrokeshire, 1926 ...	Jan.–March.	8
9. Pembrokeshire, 1927 ...	Jan.–July.	13
10. Aberystwyth Borough Survey, 1926 ...	Aug.–Sept.	51
Total ...	—	162

This makes a total of 908 samples taken from 141 different dairy farms.

In considering the figures given in the following tables, it should be noted that the conditions of milk production varied considerably. The cowsheds for instance, varied from modern stelecrete constructions fitted throughout with tubular fittings, to converted wood-corrugated-iron sheds housing two or three cows. Speaking generally, however, the cowsheds were of very ordinary construction. In all cases where reconstruction had been carried out a good deal of thought and ingenuity had been displayed in the layout of the floor and fittings, in order to facilitate cleanliness. Concrete floors, efficient gutters, whitewashed walls and regularly brushed roofs and beams were very noticeable features. With regard to milk rooms, only about 25 % of the farms had separate sheds used solely for the handling and storing of milk.

The following table gives a fair conception of the size of dairy herds kept on the farms dealt with :—

Size of herd.	*No. of farms.*
Over 20 cows in milk ...	26
10–20 cows in milk ...	63
Under 10 cows in milk ...	52

Regarding the methods of milk production, milking machines were not used on any of the farms considered in this article. Approximately 80 % of the competitors sterilised their equipment efficiently, either by means of steam or boiling water. The majority used boiling water, and surprisingly good results were obtained by this method. Many of the competitors who have learnt the importance of efficient sterilisation, are now adopting the less laborious steaming method.

The influence of efficient cooling on the keeping quality of the milk is being very slowly realised in the area. The Clean Milk competitions have, however, been of great value in demonstrating the importance of this factor. Less than 50 % of the competitors used mechanical coolers, the majority cooling their evening milk by standing the churns in water. Consumers in the towns served by the competitors still show a distinct preference for the warm morning milk. The cooling of the milk on several of the farms using mechanical coolers was found to be inefficient during summer. Temperatures ranging from 58°F to 70°F were recorded on nine farms. The contributing causes observed in these cases were :—

1. Misuse of the cooler; the rate of flow of milk and water not being regulated correctly. A tendency to rush the cooling process was observed in many cases.
2. The water used for cooling was not cold enough. Open storage tanks, surface conducting pipes and shallow unprotected wells were the defects in this case.

Uniformity of treatment was carefully considered in the laboratory. All samples taken from morning milk were examined when 26 to 30 hours old, and evening milk samples at ages which varied between 22 and 24 hours.

No ice boxes were used in despatching samples, consequently temperatures during transit varied considerably. On arrival in the laboratory, the temperature for each sample was immediately recorded. Each sample was contained in *two* eight ounce bottles. The bottle set apart for chemical tests was used for recording the temperature of the milk. The samples were then placed in a " low temperature " incubator at a constant temperature of 60°F, and kept under these conditions until required for the bacteriological and keeping quality test.

The majority of the samples taken into consideration were examined during the winter and spring months (January to June). The temperatures of the samples on arrival in the laboratory during this period varied from 51°F to 64°F.

II. Relationship between Bacteriological content and keeping quality.

A summary showing the effect of variation in bacterial content on keeping quality is given in Table I. Samples in which coliform organisms were detected are given on the right side, and samples with B. coli absent on the left side.

TABLE I.

Bacterial count per cubic centimetre.	*B. coli not found in 1 cc.*			*B. coli present in any dilution up to 1/1000 cc.*		
	No. of samples.	*Total hours sweet.*	*Average hours sweet.*	*No. of samples.*	*Total hours sweet.*	*Average hours sweet.*
0– 5,000	261	24,854	95	88	7,917	90
5,001– 10,000	48	4,390	91	53	4,218	80
10,001– 30,000	48	3,990	83	91	7,000	77
30,001– 50,000	6	486	81	59	4,558	77
50,001–100,000	14	1,057	76	62	4,434	72
100,001 and over.	16	1,155	72	162	11,058	68
Total	383	—	—	515	—	—

This table shows that :—

1. There is a steady fall in the keeping quality of the milk as the bacterial count increases. For example, the 261 samples with a count between 0 and 5,000 with no B. coli had an average keeping quality of 95 hours. On the other hand the 16 samples which contained more than 100,000 colonies had an average keeping quality of only 72 hours.
2. The presence of coliform organisms lowered the keeping quality at each stage. Samples with counts of 0 to 5,000 and no B. coli had an average keeping quality of 95 hours, whilst the average of samples with similar counts, but in which B. coli was detected, was 90 hours.
3. Different species of bacteria will taint or sour milk at different rates, for example, the influence of coliform organisms shown above. As no two samples of milk will contain exactly the same balance of species, it is obvious that variations in keeping quality will be found even in samples containing approximately the same bacterial counts. This is a point which dairy men often fail to appreciate when comparing the bacteriological and keeping quality results.
4. When a sufficient number of samples is considered, however, a noticeable correlation is observed between bacterial count and keeping quality.
5. Coliform organisms were only detected in 57 % of the 908 samples examined. These results demonstrate the efficiency attained in this line of Clean Milk production. The exclusion of coliform organisms is acknowledged to be a far more difficult task than the reduction of bacterial count. In comparison a study of Table II shows that 79 % of the " retail " samples taken in the borough of Aberystwyth contained B. coli.

These results show a close correlation in essentials with the averages for 2,476 samples given by Barkworth, Mattick, Taylor and Stenhouse Williams.[1] The actual number of hours which the samples kept sweet in the two results varied considerably. This is to be expected when one considers the influence of seasonal factors. Table II shows the effect of the variation in bacterial count on the keeping quality of a series of 102 samples

[1] Barkworth, H., Mattick, A. T. R., Taylor, M. G. D., and Stenhouse Williams, R. The relationship between the bacteriological content and the keeping quality of milk. *Journ. Min. Agric.*, Vol. XXXIII, No. 11, 1927, pp. 997-1001.

examined during the summer months—July to September 1926. The temperature of the milk on arrival in the laboratory during the period ranged from 67°F to 74°F. A comparison of the average keeping qualities for corresponding bacterial count groups in Tables I and II shows a decrease throughout of 1 to 1¼ days, but the same general deductions hold true for both series.

TABLE II.

Count.	*B. coli not found in 1 cc.*			*B. coli present in any dilution up to 1/1000 cc.*		
	No. of samples.	*Total hours sweet.*	*Average hours sweet.*	*No. of samples.*	*Total hours sweet.*	*Average hours sweet.*
0– 5,000	7	432	62	6	358	60
5,001– 10,000	3	178	59	11	636	58
10,001– 30,000	4	216	54	16	716	47
30,001– 50,000	—	—	—	8	366	45
50,001–100,000	4	209	52	11	495	44
100,001 and over.	4	193	48	28	1,190	43
Total.	22	—	—	80	—	—

III. Influence of seasonal and temperature factors.

A study of the effect of variation in transit temperature during different seasons is given in Table III.

The average arrival temperature for monthly series of samples is shown in combination with the number and percentage of samples which attain different keeping quality standards.

Three well differentiated periods can be distinguished from this table :—

1. A winter period from January to April, showing a slight increase in average temperature (58°F to 55°F). The keeping quality of the samples examined during this period shows a gradual improvement, which can be accounted for by the improvement in technique of production effected during the course of the Clean Milk Competitions.
2. The second period extending from May to July shows a considerable increase in average transit temperature (59°F to 68°F). This has had a deleterious effect on the keeping quality standard, even though the standard of cleanliness during production and handling had actually been still further improved.

TABLE III.

Keeping Quality in Days.	Period I.								Period II.						Period III.				Total Samples.
	January.		*February.*		*March.*		*April.*		*May.*		*June.*		*July.*		*August.*		*September.*		
	53° *F*		53° *F*		54° *F*		55° *F*		59° *F*.		60° *F*.		65° *F*.		69° *F*.		68° *F*.		
	Samples	%	*Samples*	%	*Samples*	%	*Samples*	%	*Samples*	%	*Samples*	%	*Samples*	%	*Samples*	%	*Samples*	%	
4 or more	8.	20.	62.	17.	101.	56.*	72.	59.*	16.	13.5	—	—	—	—	—	—	—	—	259.
3 to 4	25.	34.*	65.	49.*	75.	41.	50.	40.	85.	73.*	52.	50.*	3.	9.	1.	2.	—	—	356.
2 to 3	6.	15.	6.	4.	6.	3.	1.	1.	16.	13.5	51.	50.	29.	88.*	32.	30.*	13.	57.*	160.
Under 2	—	—	—	—	—	—	—	—	—	—	—	—	1.	3.	20.	38.*	10.	43.*	31.
Totals ..	39.	—	133.	—	182.	—	123.	—	117.	—	103.	—	33.	—	53.	—	23.	—	806.

* Shows rise and fall of maximum percentage.

3. The third phase (August to September) shows a further increase in average temperature (69°F and 68°F), allied with a further deterioration in keeping quality. The end point of the cycle seems to have been reached in August.

A general study of this table demonstrates the importance of the influence of transit temperature on the keeping quality of milk samples. As the influence of transit temperature in this case is limited to a period of 22 to 28 hours, it is obvious that the keeping quality of milk kept through its " life " period (48 to 100 hours) at atmospheric temperature is influenced to a far greater extent.[2]

It is hoped to show the influence of transit temperature on the variation in bacteriological content in a future paper.

IV. The effect of certain production factors.

Although a considerable amount of literature is now available with regard to the effect of various dairy operations upon the bacteriological content and the keeping quality of milk, some notes on the importance of the personal factor may prove of interest to those concerned in Clean Milk production.

The importance of the personal factor in the production of a milk supply, characterised by low bacterial counts and good keeping quality, has been pointed out previously.[3]

A good deal of interesting data pertaining to personal efficiency has been gathered during the course of the nine Clean Milk competitions treated with here.

Table IV shows the extent of variation in bacteriological content and keeping quality that is possible even under practically identical conditions. In this case a comparison is given of the efficiency of six milkers, during the same milking on a farm in Cardiganshire. Each milker groomed, washed and milked one cow. Open pails were used, and samples were taken immediately after straining. Every precaution was taken to make the conditions as equable as possible.

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[2] Seasonal variations in keeping quality, and the influence of the " temperature on delivery " were factors investigated by Frear, Buckley, and Stenhouse Williams during 1917 and 1918:—Kathleen Frear, Wilfred Buckley and R. Stenhouse Williams—*A study of Two types of Commercial Milk*, Cambridge University Press, 1919.

[3] Thomas, S.B. A study of some of the factors governing Clean Milk production. *Welsh Journ. of Agric.*, Vol. III, 1927, pp. 249-259.

TABLE IV.

Milked 6.30 a.m., September 12th, 1927.

Code No. of Milker.	*Bacterial count per cc.*	*Coliform organisms.*	*Keeping quality.*	
			Days.	*Hours.*
P.4.	330	Absent in 1 c.c.	2¾	66
P.1.	3,000	+ 1 cc.	2¾	66
P.2.	5,600	+ 1 cc.	2¼	54
P.6.	5,000	+ 1/10 cc.	2¼	54
P.3.	31,500	+ 1/10 cc.	2	48
P.5.	122,000	+ 1/100 cc.	2	48

The above experiment shows that a variation in keeping quality of three-quarters of a day (18 hours) is accounted for in this case by variation in personal efficiency alone. It should be noted that the samples were despatched together under the same conditions, and examined at exactly the same age, receiving identical treatment throughout.

Table V shows the influence of the personal factor in a more general way. Averages are given for 310 milk samples taken from fifty different farms in Mid and West Wales during a period extending from January to June.[4]

TABLE V.

Method.	*Average bacterial count per cubic centimetre.*	*Percentage of samples in which B. coli was detected.*	*Average keeping quality.*
1. Buildings—fair to good. General methods—excellent. Keen personal interest. (24 farms).	37,760	33%	4½ days.
2. Buildings—very inferior. General methods—excellent. Very keen personal interest. Small farms, 5–7 cows. (7 farms).	19,630	56%	4 days.
3. Buildings—fair to good. General methods—inferior. Lack of personal interest. (14 farms).	160,000	75%	3¾ days.
4. Buildings—very bad. General methods—careless and inferior. Lack of personal interest. (5 farms).	846,000	100%	1¾ days.

[4] Valuable information with regard to the conditions on the farms was obtained through the courtesy of the Agricultural Organisers and Dairy Instructresses for Brecon and Radnor, Carmarthenshire, Montgomeryshire and Pembrokeshire.

1. The two groups of dairy farms where keen personal interest was a noticeable feature obtained far better bacteriological and keeping quality results than the two groups showing lack of personal interest.
2. The seven small farms in Group 2, though having inferior buildings, were able by means of superior general methods and keen personal interest to attain bacteriological results of practically equal standard with Group 1.
3. The farms in Group 3, though having good buildings and equipment, obtained inferior results presumably due to inferior methods.
4. A comparison of the results of Groups 1 and 4 shows a very marked difference in the B. coli content and in the keeping quality results.
5. The chief problem on these fifty farms was the exclusion of coliform organisms. It is seen that under the best of conditions, as shown in Group 1, only 67% of the samples were free from manurial contamination, while all the samples in Group 4 showed traces of this type of contamination.

A comparison of the equipment and methods used, together with the results attained by two groups of competitors, will further demonstrate the importance of the personal factor. Class I in the Cardiganshire Competition (1927) was composed of eight Licensed Producers, two selling Grade A and six Grade A (T.T.) Milk. Class III in the same competition was composed of ten competitors, with herds of eight and under. Eight samples were taken from each competitor, four of which were surprise samples.

Table VI gives a comparison of equipment, methods and bacteriological results.

A close study of the technique of milk production on the various farms in these two classes, combined with a bacteriological examination, shows that, though the competitors in Class I have superior equipment and buildings, the smallholders in Class III, due to the predominating influence of personal efficiency, are able to produce a milk quite up to the standard of that produced by the "Graded" Producers. In fact it is seen that they produced a greater percentage of samples up to Grade A Standard than did the Licensed Competitors. The average keeping quality for Class I was, however, slightly better.

TABLE VI.

Item.	*CLASS I.* *8 " Licensed " Competitors, 2 Grade A and 6 Grade A (T.T.).*	*CLASS III.* *10 Competitors limited to herds of 8 and under.*
Average number of cows in herd.	17	6
Average number of milkers on each farm.	3·5	2·3
Average number of cows per milker.	5	2½
Type of sterilisation of utensils.	Boiler and steaming chamber on seven farms.	Boiling water on nine farms. Converted steaming equipment on one farm.
Cooling.	Seven competitors used coolers.	Only one competitor used cooler, majority cooled by standing churns in water overnight. Morning milk not cooled.
Percentage of competitors using covered milking pails.	63%	10%
Percentage farms with modern cowsheds.	75%	20%
Percentage farms having separate milk rooms, used solely for milk.	88%	20%
Percentage of samples up to Grade A standards.	75%	84%
Percentage of samples up to Certified Standard.	45%	41%
Percentage of maximum marks obtained for bacteriological examination of milk.	70%	68%
Average keeping quality in hours.	83·5	80

Acknowledgements.

The writers are greatly indebted to Mr. E. Hatfield for much information and advice, and to Mr. R. O. Davies for bacteriological data pertaining to the Brecon and Radnor competition, 1925.

V. Summary.

1. Statistics concerning the results of the bacteriological examination of 908 milk samples taken from 141 farms in Mid and West Wales are given.
2. A general summary is given of the conditions under which the milk is produced.
3. When a sufficient number of samples are taken it is seen that :—
   (*a*) There is a gradual fall in keeping quality as the bacterial count increases.
   (*b*) The presence of B. coli has a deleterious effect on the keeping quality of milk.
4. Coliform organisms were only detected in 57 % of the samples examined.
5. An increase of 10°F in transit temperature, 53°F to 63°F, decreases the keeping quality by a day (24 hours).
6. A difference of 18 hours in keeping quality can be accounted for by the variation in personal efficiency during milking alone.
7. Personal efficiency and methods of production have more influence on the bacteriological content and keeping quality than buildings and equipment.
8. The personal factor has a greater influence in the case of small herds, and it is found that the bacteriological standard set for Grade A milk can be easily attained by dairy farmers with herds of twelve or under.

THE SIGNIFICANCE OF VARIETY IN OATS WITH RESPECT TO YIELD AND OTHER ANCILLARY CHARACTERS UNDER NORTH WALES CONDITIONS.

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From the time the Agricultural Department of the University College of North Wales first established a College Farm in 1898 variety trials with oats have been, with few omissions, an annual feature of the cropping programme. In 1908 the College moved from Lledwigan in Anglesey to Madryn, Aber, which was again quitted in 1911 for the present College Farm adjoining. For the purpose of this paper only data from 1908 (the year of moving to Madryn) to date are considered in detail, as soil and

climatic conditions at Lledwigan are known to be materially different from those ruling at the other two farms. The area is characterised by early springs with characteristic checks to the flush of growth in April or May, due to drying east winds; and high August rainfalls usually prevail.

Plots are laid down in duplicate (though lately triplicate series have been adopted) and they vary from 1/12 to 1/6 of an acre in size. Every effort is made to obtain uniform soil conditions for the whole area, and since 1919 attempts have been made to secure the sowing of the same number of seeds (2½ millions) per acre of each variety. Neglect of this fact, having regard to the great variation in size and density of the seed grain, often accounts for thin crops and unsatisfactory results with new varieties.

New seed is sown each year, and, as far as is possible this is obtained direct from the raisers of the variety. With varieties like Record and Victory, of proved superiority for good land in the area, plots of home grown seed from the previous year, laid side by side with the new seed, have for several years past become a feature of the trials. The plots are cut separately as they mature and ripeness is determined by the disappearance of the last tinge of green from the paleae. The varieties are generally threshed straight from the field. The whole crop from a plot is weighed as it comes into the yard, the grain weight is determined, and the difference between this and the initial gross weight taken as weight of straw and chaff. Each year some black and yellow varieties are included along with the white ones. Black Tartarian, Abundance (White) and Goldfinder have been grown for fifteen, twelve and sixteen years respectively within the series.

Fifty-six varieties (thirty-eight white, twelve black and six yellow) have been grown in all. Scarcely any of these have been discarded outright after but one year's trial, but have been judged for at least two or three seasons on the basis of ancillary, non-yield characters, such as earliness of ripening, strength of straw, and quality of grain as well as of yield. It is not proposed to deal with more than the leading types of each which have proved suitable for the North Wales area.

The average of the white varieties grown is generally above that of the yellow and the black varieties. In years of high yields, such as 1925, 1909 and 1907, the white varieties excel by a bigger margin than is the case in normal years. They fall below the average of all varieties grown, however, in adverse years of drought, such as 1904, 1906, 1911, and 1919.

TABLE I.

Summary of Yield of Grain in Bushels, and Straw in Cwt. per Acre.

	Black Tartarian.		Goldfinder.		Abundance.		Average of White Varieties.		Average of Yellow Varieties.		Average of Black Varieties.		Average of All Varieties.	
	Grain.	*Straw.*	*Grain.*	*Straw.*	*Grain.*	*Straw.*	*Grain.*	*Straw.*	*Grain.*	*Straw.*	*Grain.*	*Straw.*	*Grain.*	*Straw.*
1903	38	23	52	35	43	20	40.5	23.3	50.5	24.7	38.5	29.3	55.0	24.9
1904	74	58	70	50	56	42	58.7	45.0	69.0	50.0	69.0	47.6	63.0	47.0
1905	44	29	36	25	45	19	49.0	22.5	39.0	25.3	40.5	22.5	40.0	23.0
1906	31	56	38	47	46	46	50.2	49.7	38.0	50.0	40.0	47.5	46.0	49.5
1907	87	50	81	65	94	46	90.0	45.3	77.0	45.0	84.0	57.0	90.0	46.4
1908	59	39	68	42	74	37	72.0	38.9	68.0	39.6	68.0	42.0	72.0	39.1
1909	87	58	101	57	108	55	102.0	55.3	101.0	55.0	89.0	57.0	94.6	55.3
1911	—	—	71	42	66	33	59.0	34.2	71.0	38.5	62.5	42.0	60.9	36.9
1914	72	54	85	56	79	55	84.0	53.2	73.5	56.0	80.2	55.5	80.7	54.5
1915	63	47	68	35	61	37	73.0	40.8	68.0	33.3	68.0	36.0	70.6	37.6
1916	—	—	—	—	—	—	90.0	53.7	—	43.0	87.2	—	89.3	51.6
1919	69	31	89	38	—	—	72.7	30.8	84.0	33.7	73.5	36.0	74.5	32.4
1921	58	20	60	22	64	26	68.2	23.8	62.0	22.0	55.5	21.0	64.8	23.1
1922	52	52	62	63	59	30	80.0	28.7	65.5	50.5	51.0	65.0	64.6	36.4
1923	66	38	72	41	—	—	79.2	39.8	71 0	40.0	69.5	39.5	74.0	39.8
1925	69	29	88	30	—	—	90.0	32.0	85.0	29.2	79.5	31.0	85.0	30.7
1926	59	36	65	35	—	—	72.0	33.8	63.0	32.7	65.2	35.0	66.7	33.6
Average	62	41	69	42	66	37	72.0	38.0	68.0	39.0	66.0	41.0	70.0	39.0

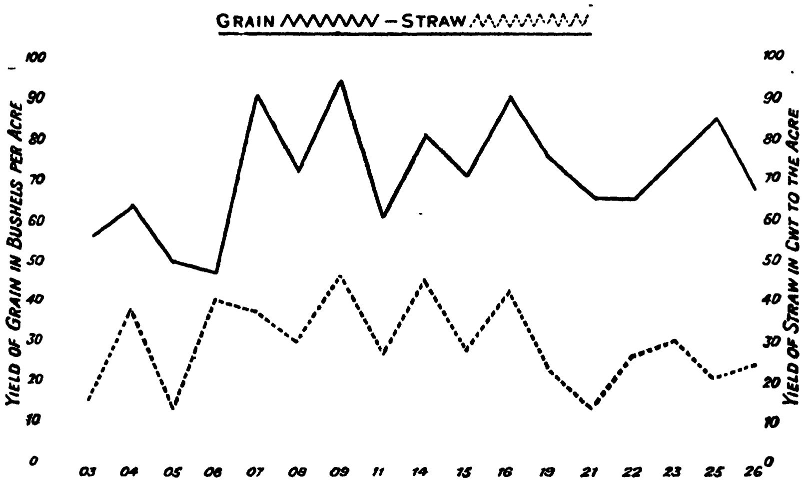
The yellow varieties are generally below the average for yield, with the exception of such years as 1904, 1911, 1919 and 1922, which have proved years of relative adversity to the white forms. Only twice (in 1904 and 1911) have the black varieties exceeded average yields for all the varieties grown.

One gathers, thus, that hardiness in respect to adverse weather conditions is a quality more generally met with in black varieties and in yellow varieties, than in white varieties, particularly with respect to hardiness against drought periods.

Relative Yield of Grain and Straw.

Table I and Graph I give, the one a summary of the yield of grain in bushels and straw in hundredweight for the different years, and the other a comparison of the fluctuations of grain and straw yields for the average of all varieties for the years. It will be seen that generally good yields of grain are concomitant with good yields of straw also. Where such is the case one would expect the season to have been one that was favourable to the crop through all its phases. Sir A. D. Hall divides the life of cereal plants into distinct stages.

A Comparison of the Fluctuations of Grain and Straw Yields for the Average of all Varieties for the years.



At first " the growth above ground is small, and the plant is almost wholly occupied in developing its root system, then comes a period of growth which lasts almost up to flowering, after which the plant as a whole no longer increases in weight, but is busy transferring the material it has already formed from the stem and leaves to the seed ".

If conditions are good up to flowering but from then become unfavourable for the proper filling and ripening of the seed, one would expect the ratio of straw to grain to be high. Another secondary consideration may, however, enter the field, the development of late tillers may, and often does, contribute to yield of straw, with no equivalent contribution to grain as these tillers seldom mature their grain in time to figure in the threshed yield. Such grain contribution, if it figures at all, does so by augmenting the proportion of tail corn.

The graphs for grain and yield depart from parallel rise or fall at some points. Straw yield is high in 1906 and 1922 as compared with the yield of grain, while in 1925 straw figures low in comparison with grain. In 1906 it will be recalled that June and July were months of severe drought, which in the later stages probably seriously reduced the migration of food materials to the grain. In 1922 excessive cold and precipitation in the post flowering period in all probability similarly crippled the migration. In 1925, on the other hand, conditions favoured the marshalling of the manufactured food products in the later stages of growth, but drought up to the end of June had reduced the vegetative growth of the plant considerably, thus resulting in low straw yield.

Apart from these deviations the rise and fall of yield of straw with respect to grain seem to run collaterally. In bulk of straw yield, as seen from Table I, yellow oats consistently lead the other types. White varieties give least straw, being slightly excelled by the black types. This is a consideration that weighs with North Wales farmers, who utilise oat straw extensively in stock feeding.

Yield of Grain.

White. Thirty-eight white varieties have been grown from time to time during these years. Most were tested only a few times and then discarded as unsuitable for our conditions. Of late years, with the extraordinary variety of seasons that we have experienced, two, which have been included each year, have proved their superiority each season. These are Record and Victory, and on the score of yield they stand unchallenged in our records for a run of several years.

Yellow. Six varieties of yellow oats have been tested against Goldfinder grown continuously as the standard type of yellow. Colossal, Golden Oat, Yellow Poland, Yellow Naasgard have been tested, together with Golden Rain. The latter alone, in trials running since 1914, has approached Goldfinder on the score

of yield. In this respect, as well as in straw yield, there is little to choose between them.

Black. Twelve varieties have been grown in all, tested against Black Tartarian in each case. The conditions at Aber are in most seasons not really those under which black oats give the best results. For our conditions Black Tartarian continues to hold its own fairly well, though from year to year it has been challenged for grain yield in turn by Bountiful, Earl Haig, and Supreme. In adverse years Black Tartarian seems to maintain its yield better than most other black forms. The trials of the last few years, however, suggest that Englebrect and Black Bell III may seriously challenge Black Tartarian on the score of yield, if their performance be repeatedly maintained.

Effect of Change of Seed.

It is commonly believed that seed oats from another district, or from a different type of soil, give better results than home grown seed, and many farmers make a regular practice of securing an occasional change. In some cases there is a good foundation for this belief. The climate may be such that in most years it is impossible to secure seed of good germinating capacity, or the local thrashing machine may be responsible for an admixture of different varieties and contamination with weed seeds. When seed is purchased it is now possible to secure a guarantee not only of good germination, but of freedom from injurious weeds.

The belief in change of seed is, however, not confined to such extreme cases as those mentioned, and farmers who can usually secure well ripened grain and are careful in their dressing of their seed corn, still make a practice of changing their seed. From time to time we have carried out experiments to compare home grown seed oats with those from other districts. For instance, in 1905, 1907, 1908 and 1909, four extensive experiments were carried out at the College Farm in which home grown "Abundance" oats were grown side by side with oats of the same variety obtained from a dozen districts representative of the whole of Great Britain. The following was the general conclusion drawn from the four trials :—

> "No advantage is gained by changing seed oats in cases where home grown seed, well dressed and of good quality, can be obtained. The plots have usually been cut on the same day, and at the outside the plot last to ripen has never been more than a few days behind the earliest. It will be seen, therefore, that the experiments have not given support

to the view which has often been expressed that harvest may be hastened by obtaining seed from an earlier district."

More recently it has been possible to obtain some information on this matter from our variety trials, which have frequently included home grown Record or Victory as well as new seed. In the case of Victory, the new seed has always been obtained direct from Svalof in Sweden. Record has been obtained direct from the raisers, Messrs. Gartons, who have grown it in different districts of England and Scotland, invariably in a drier, sunnier climate than that of North Wales.

Generally speaking, the results have confirmed those of the experiments already quoted. Home grown seed has usually given just as good results as the new seed, ripened quite as early, and given at least as good grain. There have, however, been two years in which a pronounced difference was seen, viz., 1921 and 1925. In both these seasons the home grown seed, although well harvested and of good germination (not less than 98 per cent.) proved unsatisfactory as compared with the new seed. The difference was especially noticeable in the early part of the season. Germination, though good, was slow, and the young plants appeared lacking in vigour. The favourable conditions which followed later in both summers seemed to enable the plants to get over the initial handicap, and the figures of weights of crops, etc., although tending to bring out the difference, do not reveal it to the extent which continued observation of the growing plant during the season clearly showed. The impression left was that, had the summers of 1921 and 1923 proved unfavourable, the home grown seed would have come out very badly as compared with the new seed. The explanation of this exceptional experience in 1921 and 1925 almost certainly lies in the nature of the preceding seasons. 1920 will long be remembered as one of the coldest, wettest summers within living memory, while 1924, though not so bad, was still a distinctly cold, wet season, particularly after the middle of July. The length of time from seed time to harvest was very long in 1924, from 136 to 153 days according to variety.

The experience gained in 1921 and 1925 with the seed grown in 1920 and 1924 leads us to modify the conclusions drawn from the earlier series of experiments and quoted above.

Under conditions such as those at Aber no advantage is likely to be gained by "mere change of seed" in cases where home grown oats well dressed, of good quality and true to variety are available, except when the season in which they were grown has been exceptionally cold and wet, particularly perhaps in the later stages of growth, say from the beginning of July onwards.

TABLE II.

Proportion of Kernel to Husk (Husk represented by unity).

Kernels. Crops Sown in Spring.						Husk.	Variety.	Husk.	Kernels. Crops Harvested in Autumn.					
1926	1925	1923	1922	1921	1919				1919	1921	1922	1923	1925	1926
2.76	2.79	2.03	2.80	—	2.48	1	Record (Home Grown)	1	2.08	2.67	2.81	2.30	2.45	2.33
2.71	2.66	—	2.17	2.80	2.29	1	Record (New)	1	2.44	2.85	2.82	—	2.87	2.58
—	—	—	—	2.56	1.06	1	Captain	1	1.77	2.74	—	—	—	—
2.54	2.74	2.94	2.52	3.00	2.19	1	Victory (New)	1	2.87	2.85	3.21	2.63	2.84	2.90
3.43	2.87	3.06	—	—	—	1	Victory (Home Grown)	1	—	—	—	2.65	3.03	2.72
—	—	—	—	—	2.14	1	Tartar King	1	1.61	—	—	—	—	—
—	—	—	3.37	—	2.26	1	Potato	1	1.95	—	2.90	—	—	—
—	—	—	2.30	2.72	2.50	1	Yielder	1	2.20	2.33	2.88	—	—	—
—	—	—	—	—	2.26	1	Hero	1	1.46	—	—	—	—	—
—	—	—	—	3.37	—	1	Leader	1	1.98	2.62	—	—	—	—
—	—	—	—	3.06	2.79	1	Beseker's Prolific	1	2.37	2.66	—	—	—	—
—	—	3.19	3.14	3.15	3.11	1	Wide Awake	1	1.89	2.33	3.17	2.82	—	—
—	—	—	2.92	3.11	—	1	Abundance	1	—	3.37	3.31	—	—	—
—	—	3.17	2.60	2.64	—	1	Crown	1	—	3.11	3.24	3.04	—	—
—	—	—	—	1.69	—	1	Waterloo	1	—	2.72	—	—	—	—
—	—	3.05	2.97	—	—	1	Nova	1	—	—	3.76	2.50	—	—
—	—	—	—	—	—	1	Blainslie	1	—	—	3.16	—	—	—
—	—	2.87	—	—	—	1	Irish Tawny	1	—	—	—	2.94	—	—
2.45	2.88	3.10	—	—	—	1	King	1	—	—	—	2.57	2.91	2.73
2.77	2.90	2.75	—	—	—	1	Superb	1	—	—	—	—	2.67	2.36
—	—	—	3.40	—	—	1	Sandy	1	—	—	3.25	—	—	—
—	2.87	—	—	—	—	1	Fortuna	1	—	—	—	—	2.69	—
2.83	—	—	—	—	—	1	Cropwell	1	—	—	—	—	—	2.85
3.15	3.32	2.80	3.24	3.31	2.91	1	Goldfinder	1	2.10	2.18	3.32	2.97	3.14	3.00
2.76	3.10	3.28	3.09	2.68	1.63	1	Golden Rain	1	2.74	2.98	3.33	2.78	3.30	2.60
—	—	—	—	2.78	—	1	Yellow Naasgard	1	—	2.85	—	—	—	—
—	—	—	—	2.47	2.60	1	Bountiful	1	1.51	2.68	—	—	—	—
—	—	—	—	—	2.45	1	Du Bach	1	2.02	—	—	—	—	—
—	—	—	—	—	—	1	Supreme	1	1.72	—	—	—	—	—
2.76	2.30	2.74	2.47	2.52	1.98	1	Black Tartarian	1	1.59	2.07	2.40	2.15	2.31	2.60
—	—	—	—	—	1.47	1	Black Mogul	1	1.71	—	—	—	—	—
—	2.32	3.13	2.76	3.15	—	1	Sir Douglas Haig	1	—	2.46	2.82	2.30	2.37	—
2.08	2.44	2.38	—	—	—	1	Black Bell III.	1	—	—	—	2.36	2.49	2.35
2.31	2.27	—	—	—	—	1	Englebrect	1	—	—	—	—	2.42	2.13

Home grown seed obtained in such seasons, even though ultimately harvested in good condition and giving a good germination test, may be lacking in vigour, and give a rather late unsatisfactory crop, particularly if the following season is also unfavourable. In securing a change of seed after such seasons, it would be well to go to a drier, sunnier district. As some farmers are inclined to compare seed oats with seed potatoes, where change from cooler upland conditions undoubtedly gives the best results as a rule it is necessary to emphasise the essential difference between the two crops.

Proportion of Kernel to Husk in the Grain.

This has been determined annually since 1919 for all the varieties grown, both for the seed put down in spring and for the grain harvested in autumn. The sample in the latter case is drawn in bulk from the head corn as it leaves the threshing machine. Husk and kernel of 300 grains are separated by hand in each case and their proportion by weight ascertained. These are given for 1919, 1921, 1922, 1923, 1925 and 1926 in Table II. Those for the crops harvested in autumn are the more likely to represent the real character of the varieties, as those were grown and threshed under identical conditions at Aber, while the grain sown in spring was drawn from several different sources. It is rather surprising to find that the proportion of kernel was on the whole much higher in the 1921 crop than in the 1919 one, as although the summer of 1919 was very dry and unfavourable to the growth of oats, the drought of 1921 was much more severe. The spring of 1919 was very unfavourable and it was only with difficulty that the crop could be sown on May 6. Before the crop was established, the drought of June (with average maximum temperatures of 64°F compared with 61°F in 1921 for the same period) checked its growth when the reproductive organs would be forming. In 1921 conditions were for a time favourable and the crop had a good start.

In the 1922 crop, with a few exceptions, the proportion of kernel to husk was higher in the crop harvested than in the seed from which it was grown, and in practically every case much higher than in either 1919 or 1921. The samples did not suggest this on gross examination. In all probability the difference lay in the structure or in the dryness of the husk in the various years.

It was expected that 1923 would prove a bad season for the production of well-filled grain. This proved to be the case, for, with the exception of Irish Tawny and Goldfinder, the proportion of kernel in the grain was considerably less in the crop grown at

Aber during 1923 than it was in the seed grain sown in spring. Black Bell maintained the same proportion. It seems probable that either these were grown under exceptionally severe and adverse conditions in 1922, or else that they naturally endure such wet, sunless conditions as were experienced in 1923, much better than the other varieties. This latter is presumably the more likely explanation, and probably partly accounts for the high esteem hill farmers in North Wales still have for Goldfinder. Varieties grown both in 1922 and 1923 gave a smaller proportion of kernel in the latter season.

1925 proved a good year for ripened well-filled grain, superior to the sunless wet summer of 1923. It is again shown by the 1925 results that the yellow varieties are consistently good in this respect, while the black varieties are considerably below the average. The figures for 1926 again warrant the same conclusions.

The proportions of kernel is distinctly low in the black varieties, while taking the run of the years, the yellow varieties are particularly good in this respect. Of the white varieties Victory has had on the whole a higher proportion of kernel than Record. As the proportion of kernel to husk gives an indication of the feeding value of the grain, it is hoped that, with the passing of the years, we shall accumulate data of considerable significance on such points as this, supplementary to grain yields.

Strength of Straw.

In many parts of North Wales the heavy rainfall and the amount of organic matter and nitrogen in the soils make strength of straw one of the most important considerations. Up to the present no spring sown variety of oats has been found equal to standing up under really severe conditions such as those ruling in 1926. Nevertheless there are marked differences between the varieties in this respect. Lodging, it appears, may be of two kinds, the one, more rarely met with where the straw sags or even fractures through brittleness at the internodes, and the other, more commonly met with at Aber, where the straw gets laid flat on the ground through inadequate anchoring of the coronal roots when wind and rain of high intensity come during the milk ripe stage when the plant is heavy in the heads. Record, a variety similar to Victory in colour and cropping power, is recommended in preference to Victory, in cases where the crop is likely to go down because it has all along since 1914 (when they were first tested) proved a little stronger in the straw in the variety tests at Aber.

In 1926 Black Englebrect and Record stood up best, whereas Victory, King and Cropwell were badly laid. Abundance, Goldfinder, Supreme, Captain and Yielder, to mention a few favourite varieties of the district, have also proved weak in the straw, while Crown, Golden Rain and Bountiful have consistently proved more satisfactory in this respect.

Earliness of Ripening.

Earliness of ripening is of considerable importance particularly in late districts. The economy of hill farming in North Wales is such that it is often well into May before ewes and lambs are cleared off the lowland. This necessarily delays sowing, and a difference of ten days in ripening between two otherwise similar varieties may make all the difference between a tolerable crop, and a crop that may be harvested for bedding only or indeed entirely abandoned. The number of days from sowing to ripening has been noted in the case of each variety for some years, and it will be recalled that a variety is reckoned as ripe when the last tinge of green has left the paleae or chaff.

The figures for some of the years are as follows :—

	Early.		*Late.*	
1914	Golden Rain. Bountiful. Leader.		Goldfinder.	
1915	Supreme. Leader. Golden Rain.		Crown. Goldfinder.	
1916	Supreme. Leader.		Hero.	
1919	Captain Record Golden Rain	107 days 112 ,, 114 ,,	Goldfinder Black Mogul Potato	122 days 125 ,, 130 ,,
1920	Yielder Golden Rain Captain Record	127 days 128 ,, 128 ,, 131 ,,	Bountiful Yellow Poland Goldfinder	140 days 141 ,, 143 ,,
1921	Captain Golden Rain Yielder	103 days 119 ,, 106 ,,	Goldfinder Black Tartarian	115 days 117 ,,
1922	Sir Douglas Haig Abundance Golden Rain	118 days 119 ,, 105 ,,	Potato Goldfinder	130 days 132 ,,
1923	Superb Sir Douglas Haig Black Bell III Golden Rain	125 days 125 ,, 126 ,, 126 ,,	Goldfinder Record (home grown) Record (new) Crown	133 days 133 ,, 145 ,, 145 ,,

	Early.		*Late.*	
1924	Superb	136 days	Record (home grown)	150 days
	Golden Rain	140 ,,	Goldfinder	151 ,,
1925	Superb	112 days	Victory (home grown)	123 days
	Golden Rain	113 ,,	Record (home grown)	123 ,,
	Englebrect	116 ,,	Goldfinder	123 ,,
	Earl Haig	119 ,,		
1926	Superb	114 days	Record (home grown)	123 days
	Englebrect	117 ,,	Victory (home grown)	123 ,,
	Black Bell III	119 ,,	Goldfinder	123 ,,
	Golden Rain	120 ,,	King	126 ,,

It will be noticed that in spite of several exceptions the order of varieties as regards earliness of ripening has been fairly consistent. Since 1923, when it was first introduced Superb has each year been the first to ripen. Golden Rain, Earl Haig, Yielder and Captain have also been consistently early, while Goldfinder and Crown have been consistently later. On the score of ripening the old favourites Black Tartarian and Goldfinder have little to recommend them in their respective classes. When we reckon as many as twenty days' difference in ripening, such as was experienced in 1923, we realise the importance of selecting varieties on this basis, particularly for upland and late districts. It might well turn the balance, for instance between Earl Haig, Black Bell III or Supreme on the one hand and Black Tartarian on the other. Golden Rain and Goldfinder are so similar on the score of colour and cropping powers that the early ripening propensity of the former should give it favour in the upland districts.

Conclusion.

Black oats and yellow oats are extensively grown in North Wales and so some of these have been included in the trials at Aber every year. They have proved their merit on some scores, such as high quality of grain in the yellow forms, and though on the whole, they have not done so well as the best of the white varieties, it must be pointed out that the conditions at the College Farm are hardly typical of those under which black oats and yellow oats are mainly grown. The fact that many enterprising farmers, who have tried white varieties, still continue to grow the others is evidence that for comparatively poor soils, and particularly for upland districts of high rainfall, they have a special value. In conditions, however, similar to those of the College Farm there can be no doubt that some of the white varieties are the more profitable, and that they will give not only

a higher yield per acre, but the grain will be more valuable per quarter.

Having due regard to the merits of other varieties, Victory and Record have clearly proved the most suitable white oats for the lowland districts of North Wales. In some years the one variety does rather better than the other, but over a number of years there is no great difference between them as regards weight of grain and straw, and the choice should depend mostly on the condition of the soil. Record is the stronger in the straw and in wet seasons has stood up when Victory has gone down. Victory should only be grown on the drier soils in the more favourable districts. King and Crown have given good yields, but there seems no reason to recommend either on the score of yield in preference to Record and Victory. King is decidedly later in ripening. Wide Awake has consistently given very high quality grain, combined with a good yield and can be recommended for light land with no fear of the crop going down. Yielder has not given particularly good results, but it is a strong strawed early ripening variety suitable for strong soils in the later districts. Varieties of the Potato type have been grown. They have always given late ripening, strawy crops, but a low yield of grain. They have a special value for districts where the straw is almost as important as the grain and are even extending in some parts where they displace the old-bristle-pointed oat (Avena strigosa), fed whole and unthrashed in the higher districts. For grain production, however, they cannot hold their own with the other white varieties. Though Goldfinder has proved a very hardy oat with high proportion of kernel to husk, the earliness of Golden Rain, a variety equally hardy and otherwise very similar to it, should commend this variety to upland farmers in preference to Goldfinder. It is however, advisable to cut Golden Rain before it is dead ripe as the grain is more easily shed at harvest than that of Goldfinder.

Though Black Tartarian continues to hold its own fairly well against the newer black varieties it must yield to Bountiful for good lowland conditions in North Wales. This oat is earlier in ripening, strong and long in the straw. The grain has a higher market value than Tartarian, but it is rather easily shed at harvest. Supreme, though it gives satisfactory grain yields and ripens early, has weak, though rather coarse straw. The weight of straw also is distinctly low. Similarly, though Black Bell III and Englebrect have also proved superior to Black Tartarian in cropping power and earliness of ripening it remains to be proved whether either of these can safely displace Black Tartarian for

the poorer upland districts. It is sometimes claimed that the feeding value of the straw of Black Tartarian makes up for the lower yield and inferior value of its grain, but this is at least doubtful.

THE COMPOSITION OF OLD PASTURES OF HIGH REPUTATION IN NORTH WALES.

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Introduction.

North Wales is primarily a grassland, stock raising area, while on the lowlands there is a considerable amount of cattle fattening both winter and summer. Where this has been the practice for generations, some areas, in most cases isolated fields, or groups of fields, have gained a reputation for their stock carrying capacities or for their fattening propensities. With the changed economy of farming in the last few years cattle are sent to the butcher considerably younger than was formerly the case, and a higher complement of sheep is now carried on the land that was previously almost exclusively given to the fattening of bullocks. This considerably affects the composition of the pastures, with the result that some of the fields formerly of high standard have appreciably deteriorated. In the summers of 1925 and 1926 an effort was made to ascertain the precise botanical composition of such pastures as compared with poorer pastures in the same localities. This work is now in progress. The present paper gives the botanical composition of several such pastures as ascertained in the flush of growth from April to June, with in some cases a parallel analysis of adjoining, but less meritorious, pastures.

Historical.

Good pastures carry with them an indefinable texture irrespective of the species that contribute to them. In the best fattening pastures of the Midlands, particularly in Leicestershire and Northamptonshire, there is a high proportion of perennial ryegrass and wild white clover. It is the same elsewhere except where special circumstances favour particular species, as in the rich Fen grazings, where there is a preponderance of meadow foxtail, and in the rich pastures of Meath in Ireland, with a high proportion of cocksfoot.

S. F. Armstrong (1) measured the relative proportion of ground space occupied by the different species in a number of small representative areas, notably in the excellent old pastures in the Market Harborough district of Leicestershire and Northamptonshire. Both here, and in excellent recent pastures (some 80 years old) considered to be equally good, he found that perennial ryegrass and white clover formed two-thirds of the herbage. There was less bent grass, however, in the newer pastures, while cocksfoot, dogstail and rough stalked meadow grass were more abundant. On inferior types of old pastures bent grass and weeds constituted 40-50 per cent. of the herbage, ryegrass and white clover being quite secondary.

Hall and Russell (2) in their work on pastures of high reputation on Romney Marsh found there was as regards floral type no difference which would account for the superior feeding value as compared to adjacent fields of poor performance. The notable difference observed was that on the good land the grasses were essentially leafy, with broad leaves and much less tendency to run to flower. Further, they remained green and showed much less tendency to brown than did the poor types. This difference between the life form of plants of the same species has been recognised for some time.

Smith and Crampton (3) state that this may sometimes be easily traced to the habitat they frequent. "It is also known that plants have medicinal properties differently developed according to the district from which they are derived. Recent work in Denmark and at Svalöf in Sweden shows that pasture and meadow grasses, e.g., timothy, cocksfoot, meadow fescue, and tall oat grass include a large number of forms differing very distinctly in height and habit, some remaining constant under cultivation. It is, therefore, not unlikely that some of these forms have been evolved under the artificial conditions of highly stocked pastures. The rich pastures of the Midlands may well owe their stability not merely to isolation from virgin plant association, but to a gradual natural selection of those forms of grasses and other plants which are most suited to the treatment in vogue, including grazing."

Work done since at the Welsh Plant Breeding Station, Aberystwyth (4), has definitely proved the existence of such pasture plant differences. The great number of strains and types met with amongst all herbage plants has been insisted upon: "there can be but little doubt that the influence of so called acclimatisation on any heterogenous lot grown, generation after generation, in any particular district, would merely be to kill off

those strains not well suited to the locality and to perpetuate those that are." "The great stooling capacity and leafiness of the indigenous grasses has been shown to be a striking feature and the yielding capacity judged by both hay and pasture cuts has generally been in excess of ordinary commercial lots, and in some cases as good as or better than foreign pedigree strains."

Method of Analysis of Herbage.

Twenty samples per field were drawn with a frame measuring twelve inches by one inch, the frame being tossed at random along the diagonals of the field, and the samples bulked into one representative sample. In the laboratory they were separated into species, the roots were clipped off, and the species bagged and air dried till of constant weight. As for all grassland analysis at Bangor, the final representation of the herbage of any species or group of species is in the form of a percentage by weight of the whole air-dried produce, from which the roots have been removed. The centres are considered singly or in pairs as they fall in their separate localities.

TABLE I.

	Llog Mawr. *Percentage.*	*Pant y Carw.* *Percentage.*
Agrostis (Bent grass) ...	33·5	43·5
Moss ...	15·1	5·3
Miscellaneous plants ...	14·0	5·1
Wild white clover ...	10·0	8·3
Perennial ryegrass ...	5·9	3·8
Fine-leaved fescue ...	5·8	4·5
Yorkshire fog ...	5·6	20·6
Tall oat grass ...	2·9	—
Crested dogstail ...	2·8	3·8
Cocksfoot ...	2·1	·1
Field wood rush ...	1·3	4·1
Meadow fescue ...	1·0	—
Smooth stalked meadow grass ...	Trace.	—
Yarrow ...	Trace.	·8
Red clover ...	Trace.	—

(1) LLOG MAWR AND PANT Y CARW Pastures, Llanrwst. Examined July 21st, *et seq.*, 1925.

The alluvial flats of the Conway Valley have long enjoyed a reputation for their highly productive grazings. John Williams (5) in his "Faunula Grustensis", a volume on "The Natural Contents of the Parish of Llanrwst", written in 1830, states: "The meadows in the Vale on the banks of the river are extremely fertile, consisting of the most productive kinds of poa, alopecurus, phleum, lolium, dactylis, agrostis, etc.". The name

of the first mentioned pasture, Llog Mawr ("Big Interest" or "Big Returns") is significant, while Pant y Carw ("The Deer's Hollow") suggests that at one time this was probably a deer park in the demesne of Gwydir Castle adjoining. At the present time these pastures fetch very high rents, and are very much sought by graziers. Though inland ten or twelve miles, the river Conway, on whose bank they lie, is tidal to within a mile of them.

Soil. The soil is a very deep alluvium of a heavy silt loam texture, derived mainly from shaly Ordovician and Silurian rocks with a high water table.

Management. Up to a few years ago both pastures were similarly managed. They are both subject to flooding by the river. Normally this happens seven or eight times during the winter and two or three times during the summer grazing season, and each flooding leaves a thin deposit of fine silt.

Llog Mawr (Table I). With one exception many years ago when a hay crop was taken off each year for some years in succession and the field heavily dunged afterwards, this field is regularly summer grazed. It has had no manurial application for the last twenty years, has carried no sheep or horses, but from April 1st to the middle of September it carries a heavy stock of bullocks (2½ year old making up to 13 cwt.), which it finishes with no cake feeding from July to September. It is never clipped bare in September, but is left rough to give cover for early spring growth. There is a full flush of growth by April 1st, and it takes its full complement of stock immediately. The pasture is of fine texture with a luscious appearance even in late July. The impression one receives on walking across the field suggests a much higher percentage of meadow fescue, perennial ryegrass and yarrow.

Pant y Carw (Table I). For the last six years this field has been stocked with sheep, for the last three years almost to the exclusion of all other stock (some one hundred sheep to the eighteen acre) and the change in texture is very marked. The covering has become woolly and loose, and the field is already obviously sheep sick. The harmful effect of exclusive sheep grazing is very pronounced. It has reduced the number of species. Smooth stalked meadow grass and meadow fescue have been completely suppressed, cocksfoot is near the vanishing point, while most of the superior species have been considerably reduced. This is even more marked in the miscellaneous flora, which is here but a third of that at Llog Mawr (5 per cent. and 14 per cent. respectively). The personnel of the miscellaneous flora even is materially reduced. Of the species, *Ranunculus*

bulbosus, Taraxaceum, Plantago Lanceolata, Senecio Jacobea, and *Cerastium vulgatum,* which mostly contribute to the miscellaneous flora of Llog Mawr, the buttercup and chickweed alone remain here. Bent grass has considerably appreciated and Yorkshire fog has multiplied fourfold, and the texture of these plants is obviously of a different order and of an objectionable nature.

TABLE II.

Percentage Analysis of Herbage of Aber Group.

	May, 1926. Bridge Field, Henfaes.	*June, 1926. Cae Bricks, Aber.*	*May, 1925. Cae Wig Bach.*	
			Top.	*Bottom.*
Perennial ryegrass ...	24·0	8·5	10·6	4·7
Cocksfoot ...	1·6	1·6	·5	4·0
Crested dogstail ...	8·1	6·2	9·2	10·5
Fine-leaved fescue ...	·6	7·0	6·6	8·3
Rough stalked meadow grass ...	6·7	7·7	8·1	6·5
Smooth stalked meadow grass ...	3·2	·2	—	—
Annual meadow grass	2·8	—	—	—
Meadow fescue ...	Trace.	1·9	—	—
Sweet vernal grass ...	·1	7·6	·5	7·5
Meadow foxtail ...	1·2	—	—	—
Wild white clover ...	28·8	11·6	12·3	13·2
Moss ...	2·9	·5	4·1	5·9
Miscellaneous ...	5·5	13·7	4·7	7·0
Bent grass ...	9·9	21·1	32·3	32·1
Yorkshire fog ...	4·6	9·6	10·9	4·0
Red clover ...	—	1·7	—	—
Soft brome ...	—	1·1	—	—
Yarrow ...	—	—	·2	—
Field wood rush ...	—	—	—	1·1
Birdsfoot trefoil ...	—	—	—	·2

(2) Aber Group (Table II). Bridge Field, Henfaes. Examined May 31st, *et seq.*, 1926. Cae Wig Bach (top and bottom parts), College Farm. Examined May 15th, *et seq.*, 1925. Cae Bricks, College Farm. Examined June 5th, *et seq.*, 1926. These three fields lie on the narrow fringe of lowland situated between the foothills and the eastern end of the Menai Straits.

Soil. The soil of Cae Wig Bach is a fairly heavy loam, consisting of local shaly drift with some down wash from the upland. On Cae Bricks the soil is similarly derived, but the northern boulder clay is here nearer the surface and gives it thus a heavy texture. The Bridge Field, Henfaes, lying immediately where the Aber Valley opens to the lowland, is lighter than the

others. It is in fact a stony, gravelly material on the alluvial fan from the Aber Valley.

Management. The Bridge Field is consequently rather dry. It has been down to grass many years, and has been used primarily for bullock feeding. Latterly it has carried sheep and lambs with a few store cattle in summer and with ewes on all winter. The texture of the Bridge Field is particularly good. It carries fine, luscious growth with a full bottom of wild white clover.

Cae Wig Bach has been down to grass as long as can be remembered. Long years ago it was used exclusively for bullock fattening. For the last forty years it has carried mixed stock all the year round, as it is well sheltered and well watered. It was slagged in 1910, but has since received no dressing.

Cae Bricks is a summer dairy pasture and is reckoned of a low order for grazing. The texture is poor, and it always carries a certain proportion of fog which is absent from the other two fields. This field does not seem to improve much with slagging, and though it starts well early in the season it very soon falls back. Table II gives the analysis of the herbage of the Aber group of fields. Two analyses are given for Cae Wig Bach. The soil of the lower part is lighter in nature and the grass is known to be poorer. Both parts are here included for comparison.

Apart from obvious texture differences which cannot be assessed by any analysis, the outstanding differences between these pastures lie in the low bent grass and high perennial rye-grass content of the Bridge Field as compared with the others. The high bent grass content of both parts of Cae Wig Bach as compared with Cae Bricks, notwithstanding the higher reputation and texture of the former, indicates that the condition this grass is in is a factor of more significance to the grazier than the amount of it present on analysis. As is always the case, in a field less heavily grazed the amount of miscellaneous flora present is higher and the range of personnel is wider than in a field more heavily stocked and continually grazed down. This is borne out by the high figure for miscellaneous plants on Cae Bricks.

(3) Foryd Pastures, Vale of Clwyd, Denbighshire.

Two pastures were examined in the Vale of Clwyd near the estuary of the river Clwyd, Foryd Bach examined May 19th *et seq.*, 1926, and Parc Foryd examined May 26th *et seq.*, 1926. These fields stand close to the sea in a district of much smaller annual rainfall than those previously considered.

TABLE III.

	Foryd Bach. Percentage.	*Foryd Fawr, Parc. Percentage.*
Perennial ryegrass ...	20·6	22·6
Fine-leaved fescue ...	37·0	2·2
Wild white clover ...	18·1	8·3
Smooth stalked meadow grass ...	6·4	25·1
Crested dogstail ...	4·0	8·7
Miscellaneous ...	3·9	7·1
Couch grass ...	3·7	·7
Moss ...	2·7	7·7
Cocksfoot ...	2·6	3·3
Bent grass ...	·5	1·3
Yorkshire fog ...	·3	12·8
Yellow suckling clover ...	·2	—

Soil. Foryd Bach pasture runs to sand dunes and the open sea shore. The soil itself is composed of a thin organic layer over about a foot of dune blown sand overlying alluvial clay. Parc Foryd is an estuarine alluvial clay of a rather compact structure a short distance inland. In both fields the water table is not far from the surface.

Management. As Foryd Bach is not fenced from the foreshore and contains no water supply, it is always grazed with sheep, for which it has a very fine reputation. Sheep are on it all the year round. It is the custom to bring to it in autumn wether lambs from the hill sales. Most of these are finished by Christmas with no auxiliary keep, and the rest follow by early February. It is overrun by the sea once every four or five years, but by virtue of its open texture it soon drains with very little if any harmful effect.

Parc Foryd is scheduled as permanent pasture and has been so for a very long period. Its reputation is for its stock carrying capacity more than for fattening. Over winter it is fully stocked with Welsh ewes, and, annually from May 1st it carries a mixed stock of store cattle, a head per two acres, with a heavy supplementary stock of Welsh ewes with lambs. The farmer is of the opinion that the field has doubtlessly been over stocked with sheep for the last fifteen to twenty years. Foryd Bach pasture is one of surpassing excellence for texture and for sweetness. There is a perfectly sweet sole to the pasture and no fog, the growth being green and luscious down to the soil. The earliness of the species there (members of all the grasses were actually flowering on the 19th of May), the open surface with many seedlings, together with the occurrence of couch grass, suggest that the pasture is often regenerated from self-sown, excellent species.

It is difficult to judge whether this pasture enjoys its reputation by virtue of the excellence of its species or of its texture. It undoubtedly excels in both. The percentage of fine-leaved fescue is uncommonly high, while perennial ryegrass and wild white clover represent between them two-fifths of the whole growth. The feature of Foryd Fawr pasture on specific analysis is the high proportion of perennial ryegrass and smooth stalked meadow grass; the very low representation of bent grass and the high proportion of Yorkshire fog and moss. In texture and wholesomeness as judged by the eye it is very inferior to the special type of pasture found at Foryd Bach.

TABLE IV.

	Parc Graig, Bodrwyn. Percentage.	*Cae Raels, Bodrwyn, Percentage.*	*Kiln Field, Lledwigan. Percentage.*	*Church Field, Llanfawr. Percentage.*
Perennial ryegrass ...	4·1	6·8	9·2	11·8
Crested dogstail ...	6·2	5·6	4·7	3·4
Fine-leaved fescue ...	3·9	3·8	4·9	1·2
Rough stalked meadow grass ...	2·0	·2	3·8	4·7
Smooth stalked meadow grass ...	1·5	·2	Trace	·9
Sweet vernal grass ...	·2	4·9	—	—
Wild white clover ...	36·3	18·6	34·9	43·7
Red clover ...	·2	·5	1·3	2·5
Birdsfoot trefoil ...	Trace	·7	—	—
Yarrow ...	Trace	Trace	·7	·1
Moss ...	4·2	2·6	5·2	2·6
Bent grass ...	32·0	40·7	15·9	14·7
Yorkshire fog ...	4·3	6·1	5·2	2·6
Cocksfoot ...	—	—	1·1	Trace
Timothy ...	—	—	1·2	2·0
Golden oat grass ..	—	—	—	·1
Field wood rush ..	·7	1·6	·3	—
Miscellaneous ..	4·4	7·7	11·6	9·5

(4) THE ANGLESEY GROUP OF PASTURES.

Four pastures of high reputation were examined in the island. They will be dealt with as two sub-groups on the basis of the origins of the soils on which they grow, (*a*) Lledwigan and Llanfawr, and (*b*) Bodrwyn.

Lledwigan (The Kiln Field) Llangefni. Llanfawr (The Church Field) Llangefni.

These two fields stand on either side of the main London to Holyhead road, about a mile from the county town of Llangefni, and are representative of a patch that is regarded as the best in Anglesey. They are both very early, and are under stock all the year round, with the exception of the last fortnight in March.

From the beginning of April and throughout the summer they carry a full stock of bullocks, and though the early flush of growth is very pronounced, the graziers reckon the fields at their best in the beginning of June. Both fields are on a slope facing south.

Soil. The soil at Lledwigan Kiln Field is a fairly deep loam derived from carboniferous debris mixed with some local drift in the lower parts approaching the marsh. The top part is identical with the soil at Llanfawr field across the road. The soil here is on a ridge, purely limestone residual, and derived *in situ.* The botanical analyses of the pastures are here included alongside each other and are seen to have many elements in common. The Lledwigan pasture is, however, somewhat more rough and coarse in texture, but there is no suggestion of an accumulation of objectionable fog. The cleaner sole at Llanfawr and the higher proportion of wild white clover gives a sweeter and more luscious appearance to the pasture there. The bent grass growth in each case is closely grazed, and the miscellaneous flora which is remarkably similar in the two cases is indicative of land in good heart. It is noteworthy that these pastures on limestone are the only cases where timothy was met with under grazing conditions in the whole series.

(*b*) *Bodrwyn Pastures, Llangefni.* These pastures are further inland than the two previously considered. *Parc Graig* is reckoned the very best pasture in the area and is given up exclusively to fattening cattle brought mainly in the store condition from Ireland. *Cae Raels,* which is nearer the homestead and has on occasion to carry miscellaneous stock, though it carries over a bullock an acre and fattens them in a summer grazing season (this is generally regarded as the standard of excellence for pastures in the district), was reckoned as slightly inferior to Parc Graig at the time of examination, but it was considerably more foul with miscellaneous weeds, such as creeping buttercup and daisy. It seemed to have the texture of a good pasture, but somewhat lacked the body one generally associates with such herbage.

Soil. The land in these parts lies in ridges standing out of lacustrine flats. The soil can be classified as a deep facies of the Anglesey medium loams derived from mixed debris of rocks of the Mona complex. It is very similar for both fields examined. Both fields are in permanent grass, but the farmer suggests that in his opinion Cae Raëls, which he considers slightly inferior in fattening, would excel for dairy cattle if the economy of the farm were in that direction. There is no essential difference between the personnel of the species contributing to these two swards.

The only real divergence comes in the proportions of bent grass and wild white clover respectively, the superior pasture (Parc Graig) being, as one would have anticipated, poorer in the former and richer in the latter species.

Consideration of results and general conclusions.

It has been noted in dealing with the centres singly or in groups that these pastures all lie on deep soils, easily drained and with the water table at no great distance from the plant roots. They are all early and give a flush of growth by the beginning of April. This is mostly maintained to July over the period when the grass is most nutritious. They are either on the flat, or slightly sloping with a favourable southerly aspect. The extreme earliness of the species contributing to them is evidenced by the fact that the various grasses at Foryd Bach and Henfaes were in flower in May. The plants, however, have a dwarf growth form, so that the panicles emerge at leaf level, and are consumed along with the general bottom growth and are thus prevented from seeding and running to dry fibrous growth. In this respect these pastures differ materially from later pastures where the flowering stalks are elongated, leaving a top flowering layer avoided by stock.

It is obvious that the system of management is a very significant determining factor in the maintaining of the status of these pastures. It is a well-known fact that most of our meritorious pastures are not static types ecologically, but are transitional, with a tendency mostly towards scrub and woodland or heath on the one hand, and acid moorland on the other. The fields at Llanrwst in the Conway Valley can be regarded as the only natural grassland included in this series being " periodically flooded and drained alluvial surface along a river bank " with mineral additions to the surface. Judicious management shows itself in maintaining indefinitely the conditions that favour the continuance of the grass flora. Smith and Crampton (*loc. cit.*) state that " there is always a danger of meddling unnecessarily with natural migratory grasslands ". The tendency in our wet district " is for the formation of a thick organic sod of mosses and plant remains so dense that summer rain cannot penetrate to the soil below. Hence surface rooting species (bent grass, *Anthoxanthum*, *Luzula*, etc.) take possession and deeper rooting species dwindle away ". This in North Wales easily leads to rapid deterioration of the grass and gives heathland on our rapidly leaching topography. There is slight evidence of this in the pastures examined, where a fair proportion of the heath

grasses mentioned occur. However, a combination of soil conditions and management serves to maintain apparently indefinitely the high representation of the more excellent species.

Another factor in the grazing with respect to which local practice in North Wales is in agreement with the practice of cattle graziers elsewhere is that of maintaining a flush of growth on the ground and never running it bare, at least in the early season. There is an old Welsh adage, " Tir ifanc i anifail ifanc", to the effect that the younger the grass cut or the ley, the younger the stock it is suited for carrying. Sussex and Midland graziers also favour temporary pastures, closely grazed for young stock and for dairy cattle, but for fattening cattle they will have old permanent grass and an ample cut of it. This practice differs from that of the Romney Marsh sheep graziers. They start off by grazing very heavily in spring, bringing bullocks down, if need be, to eat down the rough. It is considered essential to feed the grass down closely from the outset, and never to allow it to get long or coarse. These varying practices are particularly significant in view of recent advances in our knowledge of the nutritive value of grass at different stages of growth.

Woodman, Blunt and Stewart (6) have demonstrated the high protein content of young grass, particularly when repeatedly cut, and that the correct auxiliary for young grass is a carbohydrate rich food such as maize or barley meal or even meadow hay. Furthermore, the ratio of protein to carbohydrate on young grass is too close for an adult bullock. The writer suggests that the grazier's practice of putting young stock or dairy cattle on young grass and reserving the older grass for fattening adult beasts is a traditional reflection of such unenunciated truth in actual practice. Again, the practice of never grazing quite bare and yet never allowing the grass to get rank and fibrous has the effect of lowering slightly the protein content of the keep while still maintaining its digestibility. Can it be that this practice serves to widen the protein carbohydrate ratio to such a degree that no auxiliary carbohydrate is required to correct the protein content, which would otherwise have stood too high for such class of stock?

If we examine the species that contribute to these pastures, we can say that unlike the pastures of the Romney Marsh and like the Midland pastures examined by Armstrong, the more excellent the pasture in respect to grazing performance the higher the proportion of perennial ryegrass and wild white clover. Crested dogstail and fine-leaved fescues contribute considerably to the herbage of them all, whilst all have a fair distribution of

either or both rough and smooth stalked meadow grass. Cocksfoot figures slightly in most of the pastures; meadow fescue, sweet vernal grass, timothy, golden oat grass, tall oat grass, yarrow and red clover are found in isolated cases, but are present in insignificant quantities. Bent grass and Yorkshire fog are generally present in such large quantities as would make it difficult to associate any excellence with these pastures if these grasses were essentially bad under all conditions. A high percentage of these in pastures of ascertained excellent texture and proved performance clearly demonstrates in the field that their value is indirectly proportionate to the degree of rankness and foulness they attain.

Fagan (7) in his work on herbage plants at Aberystwyth has shown that " individual grasses show considerable variation in the percentage composition of their pasture cuts, this being almost as great as the seasonal variation. By a system of hard grazing, grasses such as Yorkshire fog and bent, which form a large proportion of the herbage of certain types of pastures, may contribute very materially to the nutritive value of such pastures ".

Dr. Woodman (*loc. cit.*) has further shown that young grass with 90 per cent. bent in it is not essentially different (in digestibility and in protein content) from grass that was mostly ryegrass and white clover. He has also shown that seasonal variations can cause more variability in the digestibility of the growth than variations in the botanical nature of the herbage.

The high proportions of bent grass and Yorkshire fog in these pastures can thus be the more readily reconciled to their performance in stock carrying and in fattening when we recall that they are seldom, if ever, allowed to grow rank and coarse, and are borne on land with high water tables and with high water retaining capacities, which are the optimum conditions to avoid seasonal variations in the growth of grass.

Summary.

1. Eleven pastures of varying grazing performances have been examined in the counties of Caernarvon, Anglesey and Denbigh, and a botanical analysis made of each on the basis of the percentage dry weight of the different species.

2. These have been grouped into lots on the basis of locality for comparison amongst themselves.

3. These have been further considered all together and some general conclusions drawn with special reference to the effect of the systems of management practised.

(*a*) They are all characterised by early growth in spring, and a steady, even performance in this respect until well into June.

(*b*) This is favoured by their lying on deep, well drained soils with favourable aspects and high water tables.

(*c*) They are mostly not static types ecologically, but transitional with a slight heath element in them; by judicious management they are so maintained indefinitely.

(*d*) They are never very closely grazed in the growing season, and yet never allowed to grow rank and coarse. The significance of this for adult bullock feeding is discussed in detail.

(*e*) They all contain a high proportion of perennial ryegrass and wild white clover, with varying amounts of other excellent species.

(*f*) They contain besides, high proportions of Yorkshire fog or bent grass or both. The significance of these grasses under good management is discussed in the light of recent grassland work at Cambridge and Aberystwyth.

Acknowledgements.

The best of these centres have been selected for further work on the seasonal variation of the pasture ingredients together with a study of the seasonal change in the chemical composition of the herbage. This work is at present proceeding at Bangor. The writer wishes to acknowledge his indebtedness to the farmers from whose fields the samples were drawn, for their interest in the work, and for the local data they so readily submitted. Thanks are also due to Prof. G. W. Robinson, M.A., of the Department of Agricultural Chemistry, for kindly supplying the information on the various types of soils.

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COMPARISON OF PASTURES BY MEANS OF SHEEP.

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Introduction.

Since it is the effect of any pasture on the grazing animal that determines the value of such a pasture, it was considered desirable to extend the scope of investigations in progress with a view to endeavouring to ascertain the best means of employing sheep in order most accurately to compare the behaviour of different swards.

Previous work at the Station (see Stapledon (4)) had shown that the sheep carrying capacity of very poor pasture could be greatly and rapidly improved by ploughing up the old sward and seeding down the land immediately with a mixture of grasses and clovers. The precise effect of the old and of the fresh sward respectively on the sheep carried, however, had not been studied in detail, and it was decided to extend the work in such a way as to ascertain the effect of the sward on the grazing animal, and also the effect of the grazing animal on the sward.

For this purpose two definite pastures were selected—a fresh temporary pasture in the first year after seeding down, and a good permanent pasture that had been regularly grazed.[1] Following on the results of previous experiments with the grazing animal, the technique employed was that of folding a small number of sheep in suitable pens on each of the pastures. The investigation was conducted in two stages. The first part was designed to ascertain the quantity and composition of the food taken by sheep when grazing on the temporary and on the permanent pastures. For this purpose mature ewes from the

[1] During recent years the mower had been run over it in June whenever the keep had got ahead of the stock.

breeding flock were folded for a comparatively short period of time—three days—and the difference between the produce left after grazing on the grazed plots and that on the control (ungrazed) plots was taken as representing what was grazed by the sheep.

The second part was designed to compare the characteristic behaviour of the sheep together with the maintenance and live weight increment of the animals grazing on the two pastures, and in addition the effect on such increment of the addition of nitrogenous manure to each pasture. For this part of the experiment young lambs[2] were used, and the grazing period was extended for ten weeks. Each pasture area was folded off into three equal parts, and the lambs were moved from one pen to the next in rotation approximately every three days, so that each area had six days rest alternating with every three days' grazing.

Description of the pastures.

The temporary pasture had been seeded down in May, 1926, with a mixture of Italian rye-grass and Montgomery red clover, whilst a suitable permanent pasture occupied an adjoining field, both fields having the same general soil and other characteristics. The soil was of a light shaly nature; the experimental areas were on level ground in an exposed position standing at an elevation of 450 feet above sea level.

The botanical nature of the pastures is given by their analysis (percentage productivity) on June 14th.

	Per cent.
Temporary pasture.[3]	
Italian rye-grass	42·6
Montgomery red clover	57·0
Miscellaneous plants	0·4
Permanent pasture.	
Yorkshire fog	31·9
Crested dogstail	12·1
Bent	9·9
Rough stalked meadow grass	8·7
Fine-leaved fescues	8·3
Cocksfoot	7·2
Sweet vernal grass	6·1
Wild white clover	8·8
Weeds and withered portions	7·0

[2] Lambs were used for this part of the experiment as the small area available would carry a larger number, and also because they would be in a more suitable stage of growth. The lambs were of the Kerry Hill breed (home bred) and were from three to four months old at the commencement of the experiment. They had been weaned the previous week, being in store condition and weighing on an average 60 lb.

[3] It may be remarked that the area necessarily selected to represent temporary pasture did not by any means represent an ideal temporary sward for sheep grazing. The ley was in fact put down for the production of seed of a particular strain of red clover. Better grazing swards have been attained by the use of other mixtures containing wild white clover. (See, for example, Stapledon and Hanley (7)).

I. Comparison of the amount and composition of the fodder consumed by sheep when grazing on temporary and permanent pastures.

Both pastures were grazed at intervals the previous winter (1926-27) by sheep, and after a fairly close grazing the permanent pasture was " kept " from the end of March, while the temporary pasture was " kept " from the end of April. A typical area of each pasture was then selected and hurdled off into folds.

On the temporary pasture six folds of 12½ yards by 10 yards (approximately 1/40th acre) were constructed, and on either side of each fold a control portion 12½ yards by 5 yards (approximately 1/80th acre) was marked off. On the permanent pasture four such folds were constructed with corresponding control portions. On May 17th one weighed sheep[4] was put into each fold, and allowed to remain there for three complete days. These sheep had been selected so that the average weight of those on the temporary pasture was approximately equal to the average weight of those on the permanent pasture. On May 20th each of the grazing plots and control plots was cut as close to the ground as possible, first by means of a horse mower and then with a lawn mower, and the produce of each area was weighed separately. The produce was collected and weighed as quickly as possible so as to obviate loss of weight due to drying. A representative sample of each plot (2 lb. in weight) was taken at this stage. These samples were air-dried to a constant weight to ascertain the amount of air-dried matter (the equivalent of well made hay) in each plot.

Comparison of the pastures in regard to the amount of food consumed by sheep.

The relative consumption per head off each pasture is shown in Table I.

TABLE I.

To show the consumption of herbage per head per day. May 17th–20th, 1927.

Pasture.	*Number of sheep.*	*Average weight of herbage consumed.*		*Per cent. air-dried of green fodder.*
		Green.	*Dried.*	
		lb.	lb.	
Temporary ...	6	15·5	2·9	18
Permanent ...	4	10·0	2·2	22

[4] These were Kerry Hill ewes from the breeding flock, weighing on an average 130 lb. Their lambs had been sold off fat a month previously.

The amount of grass consumed per head per day clearly indicates how much more an animal takes off one pasture than another. On the temporary pasture the animal was induced to consume half as much again as on the permanent one. Not only does the amount vary in the green fodder consumed, but even when the dry fodder is taken into consideration the sheep on the temporary pasture consumed one-third more than those on the permanent one, thus showing that the method of comparing the value of pastures merely on their sheep carrying capacity alone, as measured by the product of the head of sheep and the number of days during which the keep lasts, is not satisfactory where the nature of the pastures differs widely. In the light of recent work by Davies (2) the difference in the behaviour of the sheep is probably explained to some extent by the variation in succulence between the pastures, as shown by the figures in column 5 of Table I, which indicate that samples from the temporary pasture lost appreciably more moisture than those from the permanent one during the process of drying into hay.

TABLE II.

To show the dry weight composition of the fodder taken up by the sheep when grazing the "temporary pasture". May 20th, 1927.

	Grass.			Clover.		Weeds.	Total.
	Leaf.	*Stem.*	*Leaf.* / *Stem.*	*Leaf.*	*Stem.*		
	lb.	lb.		lb.	lb.	lb.	lb.
Produce on control plot (ungrazed)..	7.60	3.24	2.35	0.43	0.03	0.38	11.7
Produce on grazed plot	1.85	0.91	2.03	0.22	0.01	0.11	3.1
Fodder consumed by 1 sheep in 3 days	5.75	2.33	2.47	0.21	0.02	0.27	8.6
Fodder consumed per sheep per day	1.92	0.78	—	0.07	0.01	0.09	2.9

TABLE III.

To show the dry weight composition of the fodder taken up by the sheep when grazing the "permanent pasture". May 20th, 1927.

	Grass.			Clover.		Weeds.	Total.
	Leaf.	*Stem.*	*Leaf.* / *Stem.*	*Leaf.*	*Stem.*		
	lb.	lb.		lb.	lb.	lb.	lb.
Produce on control plot (ungrazed)..	6.31	4.52	1.40	0.10	—	0.37	11.3
Produce on grazed plot	2.68	1.84	1.46	—	—	0.18	4.7
Fodder consumed by 1 sheep in 3 days	3.63	2.68	1.35	0.10	—	0.19	6.6
Fodder consumed per sheep per day	1.21	0.89	—	0.03	—	0.06	2.2

It is interesting to compare the consumption on the temporary pasture in this experiment with the results obtained

by Stapledon and Jones (8) on somewhat similar temporary pasture, and where the sheep used were of the same type and size. In the earlier trials the sheep consumed 2.6 lb. per head per day of air-dried matter, when the pasture was less succulent than the present one, and 3.4 lb. per head per day when the pasture was rather more succulent.

Though the amounts of foodstuff offering on both pastures in the case of the trials now under review were about equal, namely, 11.7 lb. per plot on the temporary pasture and 11.3 lb. per plot on the permanent pasture (see Tables II and III), the composition of the two pastures was very different, not only in regard to the species present in each, but also in the proportion of leaf to stem in the grasses. In the permanent pasture the grasses had a leaf to stem ratio of only 1.40 to 1, whereas the grass in the temporary pasture had a leaf to stem ratio as high as 2.35 to 1. The ratio of leaf to stem was not much altered on the permanent pasture by grazing, but in the case of the temporary pasture that ratio had been considerably reduced. During their grazing, therefore, not only did the sheep on the temporary pasture pick up more fodder, but they also picked up a much higher proportion of leaf to stem, that is to say, they consumed a decidedly more nutritive ration that on the permanent pasture (see Fagan and Jones (3)).

In this connection it is interesting to note that taking the average figures for maintenance as given by Wood (9) the sheep on the "permanent pasture" consumed barely sufficient dry matter to supply the requirements in starch equivalent for a maintenance ration, whereas the sheep on the "temporary pasture" consumed a sufficiency of dry matter to leave a substantial margin in starch equivalent over and above the requirements for maintenance. The sheep on the "temporary pasture" would therefore have been expected to have gained in weight.

II. Comparison of the live weight increment on temporary and on permanent pastures.

The pastures dealt with in Section I were again used, but in the meantime one half of each had been dressed with manures: half the temporary pasture was given a dressing of nitrate of soda at the rate of 2 cwt. per acre on May 30th and again on June 27th, whilst half the permanent pasture was given on May 30th a dressing of nitrate of soda at the rate of 2 cwt. per acre, Kainit at 3 cwt. per acre, and basic slag at 5 cwt. per acre, with a second application of nitrate of soda on June 27th at the rate

of 2 cwt. per acre. The different areas may henceforth be referred to, therefore, as "temporary manured", "temporary unmanured", "permanent manured", and "permanent unmanured".

On each area three folds of 12½ yards by 15 yards were erected, and at midday on June 14th three lambs were placed in the first fold on each of the areas. By this time, however, the "temporary manured" area had made decidedly more growth than the three other areas and, therefore, it was considered advisable to put two additional lambs on it. The four groups of lambs were selected so that the representatives of each should be as equal as possible in average size, condition, and weight. Drinking water was supplied by means of a shallow trough in each pen. Subsequently the lambs were moved every three days from fold to fold on their respective areas, so that every nine days each fold had been subjected to three days grazing and six days rest.

Weather permitting, it was the intention to weigh the lambs[5] as nearly as possible at weekly intervals, but owing to the wet weather some of the intervals extended to a fortnight. At each weighing, precautions were taken to ensure that the lambs were perfectly dry and also as far as possible in the same state of "fill". It was noticed that whenever the lambs were turned into a fresh pen they invariably started to graze actively. Further, the period of this active grazing was observed to vary from ½ to 1½ hours; the precise duration was probably determined by the state of "fill". At first, therefore, the lambs were weighed twice at each weighing date, the first weight being taken on the plot which they happened to be grazing at the time. Immediately afterwards the lambs were turned into a fresh fold and after an interval of 1½ hours the second weighing took place. Only in very rare cases[6] was there any decrease in weight after this interval, whilst the gain in weight generally ranged from 1 to 2 lb. per head. The general trend of the weights per lamb showed that the second weights—weight when "full"—gave a more uniform increase than those of the first weights, and at subsequent dates weights were only taken after a period of 1½ hours on the fresh pen.

It was also found that whenever a lamb was troubled either with maggots or with footrot there was a rapid loss in weight.

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[5] The weighing was carried out on the plot by means of a steelyard suspended by a tripod.

[6] The decrease in weight in such cases was very probably due to urinating.

When such cases occurred the average increase for that week was taken from the other two lambs in the pen involved, and the affected lamb was replaced by a lamb from an "emergency pen", where lambs not included in the experiment were kept on a similar pasture.

By July 2nd the five lambs (two in excess of the other plots) were proving more than equal to the growth on the "nitrogened temporary pasture", and were consequently reduced to the same number as on each of the other plots.

Early in August the poorer plots showed signs of overstocking. Nevertheless, the period of grazing was continued until the end of August, when it became impossible to carry this number of lambs any further, whilst it was felt impracticable to continue the trial with a reduced number of lambs.

TABLE IV.

To show the live weight increment per acre per day on various pastures as the season advanced.

	Temporary.			Permanent.			Average for temporary and permanent pastures
	Nitrogen area.	*No manure area.*	*Average.*	*Nitrogen area.*	*No manure area.*	*Average.*	
	lb.	lb.	lb.	lb.	lb.	lb.	lb.
June 14—July 9	9.8	5.0	7.4	4.5	3.0	3.7	5.6
July 9—July 26	5.9	4.4	5.1	4.4	4.2	4.1	4.6
July 26—Aug. 29	3.4	0.7	2.1	3.4	1.0	2.2	2.1
Average for total period (June 14—Aug. 29).	6.0	3.0	4.5	4.0	2.3	3.1	3.8

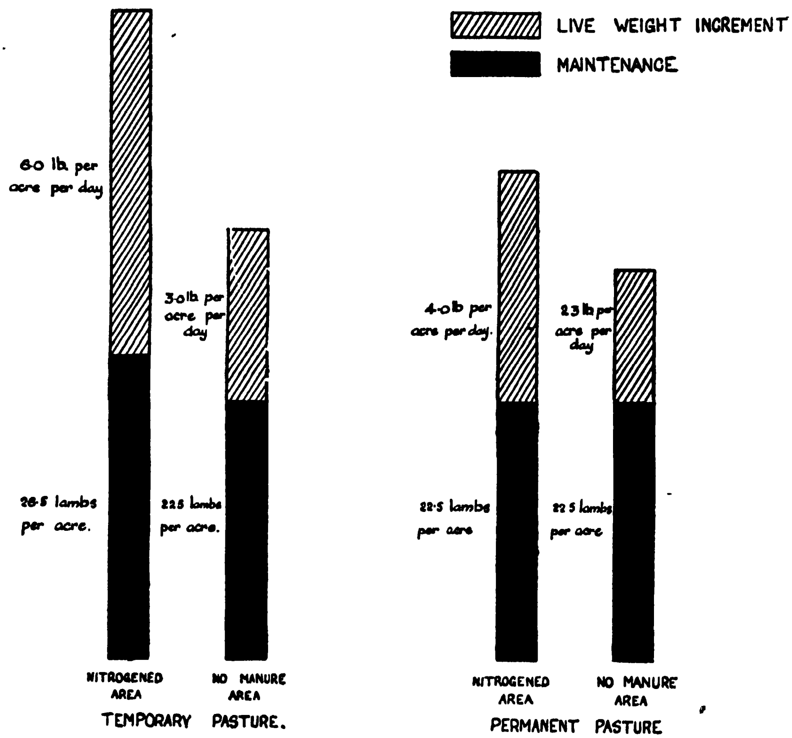
As pointed out earlier in this article, the limitation in area and the restricted number of animals consequently used in this experiment somewhat detracts from precision, but nevertheless the results as shown in Table IV and Chart 1 serve to bring out a number of striking features in regard to the value of the different pastures.

The deterioration in the productive value of the pastures when estimated by live weight increase per acre per day as the season advanced was very pronounced—the June growth on the average of all the plots both temporary and permanent, manured and unmanured, giving an increment of 5.6 lb. per acre per day; the July growth gave an increment of 4.7 lb. per acre per day, whilst the August growth gave only 2.1 lb. per acre per day. A similar falling off in productive value as the season advanced has been previously noted by Stapledon, Fagan and Williams (6). This "periodical value" of pastures is one of the chief difficulties

with which the ordinary farmer has to contend—a certain constant head of stock has to be carried right through the year, whilst the production of his grassland varies continually. From the data shown in Table IV it will be observed that, with the exception of the poorest pasture, the " unmanured area " in the permanent section, all the pastures had attained to their maximum production in June, whilst the poorest pasture showed a similar period of maximum production but later by about a month.

CHART 1.

Showing the maintenance in lambs per acre and live weight increment in lb. per acre per day on various pastures. June–August, 1927.



This deterioration in " periodical value " took effect much more suddenly on the unmanured areas than on the plots dressed with artificial manures (including sodium nitrate). The unmanured areas, taking the average of both temporary and permanent pasture, showed a fall in production from 4.8 lb. per acre per day in July to 0.9 lb. per acre per day in August, whilst the fall in production on the sections receiving nitrogenous manures on both pastures was only from 5.2 lb. per acre per day

in July to 8.4 lb. per acre per day in August, thus showing how the farmer can by judicious application of manures to his pastures extend their productive period, and regulate to an appreciable extent this " periodical value ".

It may be remarked that under the conditions of this experiment, as the number of animals per area was more or less fixed, the point of overstocking was soon reached. From that point onwards the closeness to which the animals grazed had a greater adverse effect on the temporary pasture with its open sward (small number of plants per area) than on the permanent pasture with its dense sward. That the temporary pastures fell in productivity from 7.4 lb. per acre per day in June to 2.1 lb. per acre per day in August, whilst the permanent pastures fell in productivity from 8.7 lb. per acre per day in June to 2.2 lb. per acre per day in August, indicates that the crucial point of overstocking, sufficient to cause a reduction in production, is reached far sooner in the case of the temporary open sward than in that of the permanent dense sward.

Even with the adverse effect from overstocking of the temporary pasture the higher production as compared with the permanent one is well marked—the temporary pastures giving an increment of 4.5 lb. per acre per day throughout the period, whilst the permanent pastures gave only 3.1 lb. per acre per day. To this live weight increment on the temporary pasture should be added the extra maintenance of 800 sheep days over and above the 1,710 sheep days on the corresponding plots in the permanent section. Further, all the evidence indicates that, had the unmanured area in the temporary section not been so heavily overstocked, its production would have been much higher, so that the superiority of the temporary over the permanent pasture in this case would have been enhanced still further.

It is instructive to note that, taking these results for the total grazing period as a whole, the temporary pasture gave a higher response to nitrogen than did the permanent. Thus, putting the average daily live weight increment per acre on the unmanured sections for both temporary and permanent at 100, the increments on the manured sections for each were respectively temporary 200, and permanent 174.

III. Comparison of the behaviour during twenty-four hours observation of lambs on temporary, on permanent, and on rough pastures.

The chief functions performed by an animal living a quiet life on a pasture may be conveniently considered as grazing,

chewing the cud, and resting—whether awake or asleep. With a view to ascertaining the behaviour of sheep on various pastures with regard to the time spent in performing each of these functions the method previously described by Stapledon and Jones (8) was extended to cover three different pastures—the temporary and the permanent pastures previously referred to, and a rough pasture of a distinctly inferior type.

The rough pasture was on a heavy clay soil not well drained, and the herbage was known to be rejected by animals when also given access to other fields. The following analysis (percentage productivity) of the pasture when the lambs were folded on June 14th, 1927, shows the botanical composition :—

	Per cent.
Yorkshire fog	14·6
Fine-leaved fescues	11·5
Sweet vernal grass	11·9
Crested dogstail	6·4
Meadow fescue	3·6
Perennial rye-grass	2·0
Rough stalked meadow grass ...	1·8
Rushes	9·3
Carices	12·3
Other weeds (mainly crowfoot) ...	26·6

On this pasture a fold was erected and three lambs put in it in the same way and at the same time as on the other pastures.

Method of estimating the behaviour of the lambs.

The period of observation commenced at 6 p.m. on June 14th and continued till 6 p.m. the following day. The weather was ideal, the night being calm and clear with the moon shining, while the day was dry, but not sufficiently hot to cause disturbance of the sheep by flies.

Observations were taken every five minutes on each individual lamb[7], and the method adopted was to record every time whether the animal was grazing, chewing cud, or doing neither, and also whether standing or lying down. Though observations were taken on the lambs enclosed on both the nitrogened section and the unmanured section of the temporary pasture, the behaviour of the two groups agreed so closely that in Chart 2 the data for the temporary pasture have been averaged. On the permanent pasture the conduct of the experiment rendered possible continuous observation of only those on the manured section.

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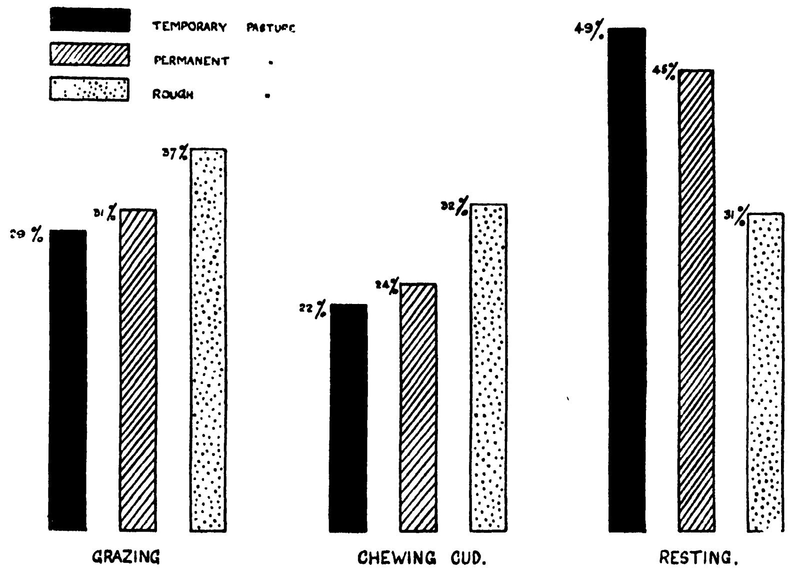
[7] Each lamb had been previously marked quite plainly so as to make identification easy during the day and possible during the night in the moonlight.

The general behaviour of the lambs during the period may first of all be considered. From this aspect there was a marked similarity not only between lambs of the same pen but also between those of all the pens. The difference between the lambs occupying different pens was simply one of degree, the times of maximum grazing activity or resting coinciding in each case, the variation being in the duration of each period. Chart 3 has, therefore, been prepared to show a typical case of the behaviour of a lamb on the succulent temporary pasture and a typical case of the behaviour of a lamb on the rough pasture.

CHART 2.

Showing the behaviour during 24 hours observation of lambs on typical pastures. June, 1927.

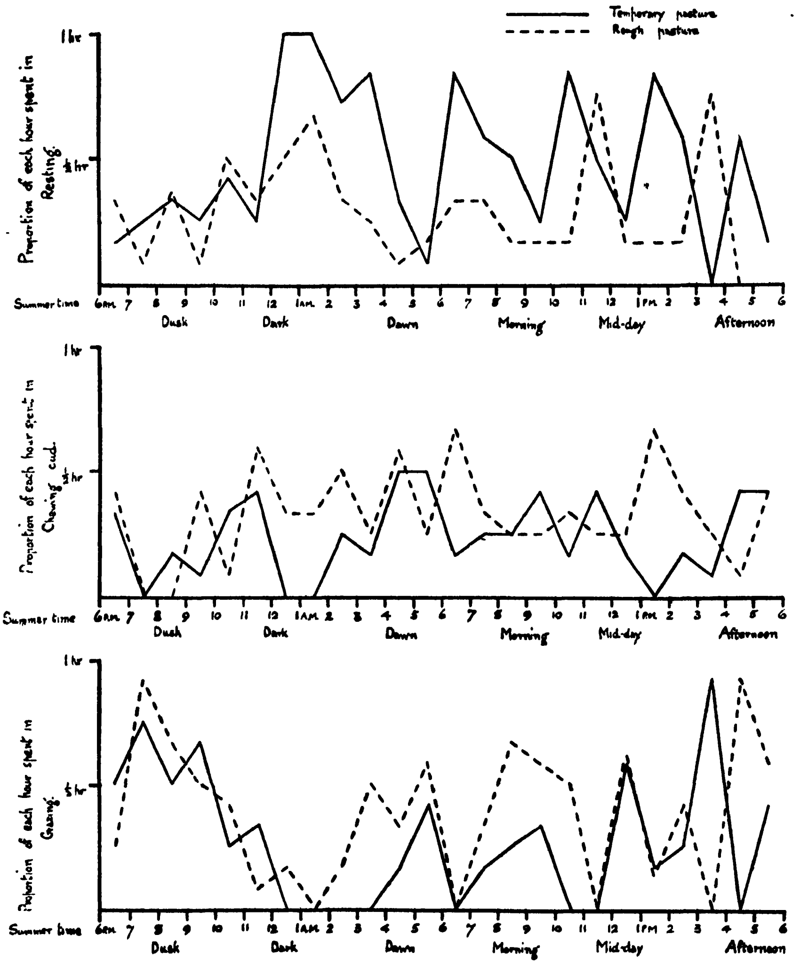


From the charts it will be seen that the lambs devoted the period of darkness mostly to rest, whereas they were most active in feeding—grazing and chewing the cud—soon after daybreak, and again in the evening. Their activity during the evening consisted mainly in grazing, whilst at dawn they spent most of their time in chewing the cud. During the day, spells of rest were taken at intervals of approximately four hours, these alternating with spells of grazing. The lambs had to chew the cud, however, much oftener than they rested—about one-third of each hour being spent in doing this. The only exception was in the evening, when practically all the time was spent grazing. The lambs usually lay down whilst chewing the cud, but after long periods

of rest, chewing the cud was sometimes resorted to in the standing position.

CHART 3.

Showing the behaviour during 24 hours' observation of a typical lamb on temporary pasture, and of a typical lamb on rough pasture. June, 1927.



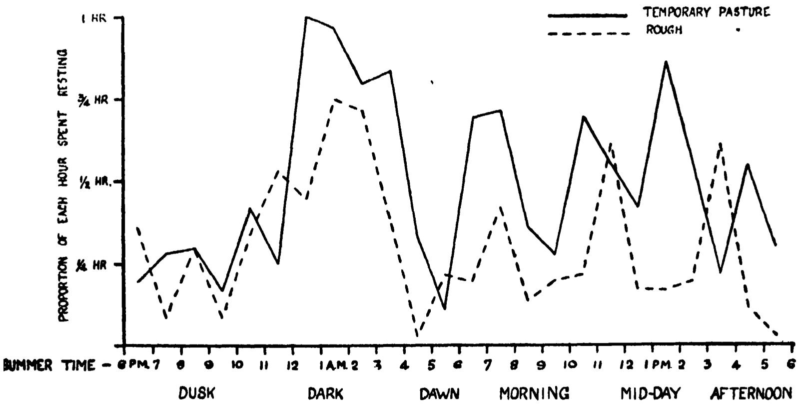
Comparison of the behaviour of the lambs on the various pastures.

The agreement between the times spent by the individual animals on each plot was remarkably good, so that though the data recorded for each plot were collected from three lambs only, they none the less serve to bring out the contrast between the behaviour of animals when put to graze on pastures of widely differing types.

A very real and impressive difference in behaviour between the lambs on the pastures may be observed by reference to Chart 2, where the length of each column represents the average time spent by the lambs in performing each of the three functions —grazing, chewing the cud, and resting. When the behaviour of the lambs on rough pasture is compared with the behaviour of those on the succulent temporary pasture, it will be seen how the extra time spent in grazing, and even more so in chewing the cud, necessarily afforded them much less time for rest. Chart 3 shows a typical case representing the behaviour of two lambs, one on the succulent pasture and the other on the rough pasture, for the complete period of twenty-four hours. The most striking feature is the almost continuous regularity in chewing the cud on the rough pasture at every hour, even during the hours of darkness, thus allowing but little opportunity for complete rest, whereas the lamb on the temporary pasture had four long spells of rest during the day, and complete rest for several hours together during the night.

CHART 4.

Showing the average period spent in resting by the lambs on the temporary and the rough pastures during the 24 hours observation. June, 1927.



The differences between the times spent by the lambs on the two pastures in lying down is not nearly so wide, though they vary in the same direction as those for resting. One very important point is brought out here in respect of the contentedness of the sheep on their respective pastures. The lambs on the succulent pasture not only spent more time in resting (not grazing or chewing the cud) than those on the rough pasture, but they spent a considerably higher proportion of this time (79 per cent.

as against 68 per cent.) lying down, and thus obtaining true rest. (See Chart 4). The lambs on the rough pasture when not grazing or chewing the cud would often get up, and then after taking a few bites would stand motionless, as if anxious to graze but not prepared to take the fodder offering.

On the other hand, the lambs on the rough pasture spent 60 per cent. of the lying down period in chewing, thus leaving only 40 per cent. for true rest, whereas on the succulent pasture the lambs spent only 31 per cent. of this period in chewing cud, thus leaving 69 per cent. for true rest. This suggests very strongly that the lying down period spent in chewing cud is not true rest in the same sense as lying down not chewing.

The behaviour of the lambs on the permanent pasture represented a state of affairs intermediate between those on the two extremes considered, but approaching much more closely to that on the succulent temporary pasture.

The live weight increment on the temporary compared with that on the permanent pasture is such as to afford fairly good reason for supposing that this difference in the proportion of time spent resting and also in chewing the cud on the various pastures probably gives a very useful index of the nutritive value of such a pasture, and also an important indication of the nature of the pasture, that is to say, whether it is suitable for production in the form of live weight increment or merely for the maintenance of the grazing animal.

There is no apparent reason why this method of estimating the feeding value of pastures could not be extended further to estimating the feeding value of the different species and strains of plants, and still further to fodder hand-fed indoors, by observing the amount of time spent by cattle or sheep in chewing the cud.

IV. Effect of grazing on temporary and on permanent pastures.

In order to investigate the effect of grazing on the different swards, representative samples were taken off each plot when the lambs were "turned in" and again when they were "turned out". These samples were separated first into grasses, clovers, and weeds (see Table V), and then the grasses and clovers were further divided into leaf and stem (see Table VI).

TABLE V.

To show the percentage composition of the pastures with regard to species before grazing and after grazing. 1927.

Date.	Treatment.	Temporary.				Permanent.					
		No Manure Area.		*Nitrogen Area.*		*No Manure Area.*			*Nitrogen Area.*		
		Grass.	*Clover.*	*Grass.*	*Clover.*	*Grass.*	*Clover.*	*Other Plants.*	*Grass.*	*Clover.*	*Other Plants.*
May 20	Ungrazed Plot	95.9	4.1	—	—	95.9	0.9	3.3	—	—	—
May 20	Grazed Plot	92.3	7.7	—	—	96.1	—	3.9	—	—	—
June 14	Before Grazing	42.8	57.2	44.0	56.0	86.8	8.8	4.6	90.2	3.8	5.9
June 20	After Grazing	34.4	65.6	33.7	66.3	90.9	4.4	4.7	92.9	2.0	5.0
July 4	Before Grazing	42.8	57.3	61.7	38.3	99.6	0.4	—	100.0	—	—
July 9	After Grazing	34.2	65.8	54.0	46 0	92.0	6.7	1.3	100.0	—	—

TABLE VI.

To show the proportion of leaf in the pasture (percentage $\frac{\text{leaf}}{\text{leaf + stem}}$) before grazing and after grazing. 1927.

Date.	Treatment.	Temporary.				Permanent.			
		No Manure Area.		*Nitrogen Area.*		*No Manure Area.*		*Nitrogen Area.*	
		Grass	*Clover*	*Grass*	*Clover*	*Grass*	*Clover*	*Grass*	*Clover*
May 20	Ungrazed plot	70	93	—	—	58	—	—	—
May 20	Grazed plot ..	67	94	—	—	59	—	—	—
June 14	Before grazing	37	63	41	53	43	73	51	76
June 20	After grazing..	26	54	30	45	28	75	46	75
July 4	Before grazing	37	53	46	39	65	—	74	—
July 9	After grazing..	32	35	42	34	67	—	71	—

For similar comparison of the grazing effect during May, representative samples from the grazing plots and from the control plots taken at that time were also analysed in the same way.

The composition of the sward on the temporary pasture at different dates showed great variation (see Table V), which was due to three factors, namely, the period of the year, the manuring, and the grazing.

The effect of the period of the year on the composition of the sward is shown in the increased proportion of clovers to grasses during June and July in both the manured and unmanured sections.

The manuring (including nitrogenous fertilizers) showed little effect on the proportion of grass to clover on June 14th, but by July 4th there was a very distinct difference; the no-manure area still showed a preponderance of clover to grass, whereas the nitrogened area already showed a preponderance of grass to clover. By the end of August, however, there was no visible difference due to manuring, both sections being practically pure Italian rye-grass. It will be noted that the proportion of grass leaf to grass stem has been increased on both pastures by the application of nitrogenous manures, while the effect has been markedly in the opposite direction in the case of the clover on the temporary sward.

The effect of management in controlling the period at which the sward was grazed was very pronounced at the end of August. This was shown when the portion under experiment, and, there-

fore, grazed throughout the summer, was compared with the remainder of the field. The latter, destined to produce a seed crop of Montgomery red clover, had been grazed continually till the end of May and then " put up ".

The portion under experiment had a sward which was practically pure Italian rye-grass, while the remainder of the field had a crop which was practically pure clover. The cause of this difference in composition due to management may be explained as follows :

On the seed production area the Italian rye-grass, which had been actively growing throughout May and at the same time continuously defoliated, had been considerably weakened. The red clover during the same period (May), however, had not commenced its period of active growth, and so the grazing had very little adverse effect on it. When the field was " put up ", the red clover, having received no check, assumed its active growth stage unhampered, and the weakened Italian rye-grass suffered very badly in the competition, with the result that by the end of August the clover was completely dominant to the grass, the respective produce being approximately in the proportion of nine clover to one grass. In the portion of the field under experiment the rye-grass again afforded the keep during May, but in June the clover sprang up considerably. As it sprang up it was repeatedly cut down by the grazing animal, particularly its leaf, until it was weakened. In July, with the " keep " becoming less abundant, both the rye-grass and the clover were kept rather short, and this at a time when the clover would normally be exerting itself to the full in order to send up a flowering stem. During August, with the " keep " distinctly short and the number of animals constant, the point of overstocking was soon attained on the plots, and both species were severely taxed. The clover failed to stand the treatment and became practically non-productive, being crippled so badly that when the pasture was rested afterwards the plants made extremely little growth. The rye-grass plants on the other hand, though severely handicapped in growth by overgrazing, did manage to recuperate fairly well afterwards when rested, so that the pasture grazed throughout the summer and particularly heavily in July and August had become a practically pure grass pasture by the end of the summer. Another feature shown by the relative proportions of grass to clover in the samples before grazing and after grazing (see Table V) is the manner in which the sheep on the temporary pasture showed a preference all along

for the grass species present[8], while on the permanent pasture a preference was shown for the clover. This phenomenon was largely governed by the relative palatability of the various species present in each pasture. The temporary one contained Italian rye-grass and Montgomery red clover, the latter being slightly hairy, whilst the former is the most palatable of all our pasture grasses when kept so short as to prevent the production of stem (see Davies (2)).

The clover species in the permanent pasture on the other hand was wild white clover, which is perfectly glabrous, whilst the predominant grass was Yorkshire fog, which is very hairy. The fine-leaved fescues, which are very low in the palatability scale, were also much in evidence amongst the grasses. The only case where the proportion of clover increased during grazing in the permanent pasture was in the July grazing on the unmanured plot. There the total bite was very small, and it is likely that under the extra heavy stocking the wild white clover, owing to its prostrate habit, was favoured in its competition with the grasses, and this at a time when it was in its most active stage of growth. When the bite was plentiful on the other hand, not only did the grasses, owing to their taller nature, affect it adversely, but they also caused it to lift its leaves higher from the ground and thus within easy reach of the grazing animal.

Another well known fact, which is substantiated by the data in Table V, is the effect of nitrogenous manure in increasing the proportion of grass to clover on both temporary and permanent swards when kept under grazing conditions.

The greatest effect of selective grazing on a sward is seen, however, in the constant selection of leaf in preference to stem both in the grasses and clovers. This is much more pronounced, however, in the temporary pasture than in the permanent one (see Chart 5 and Table VI).

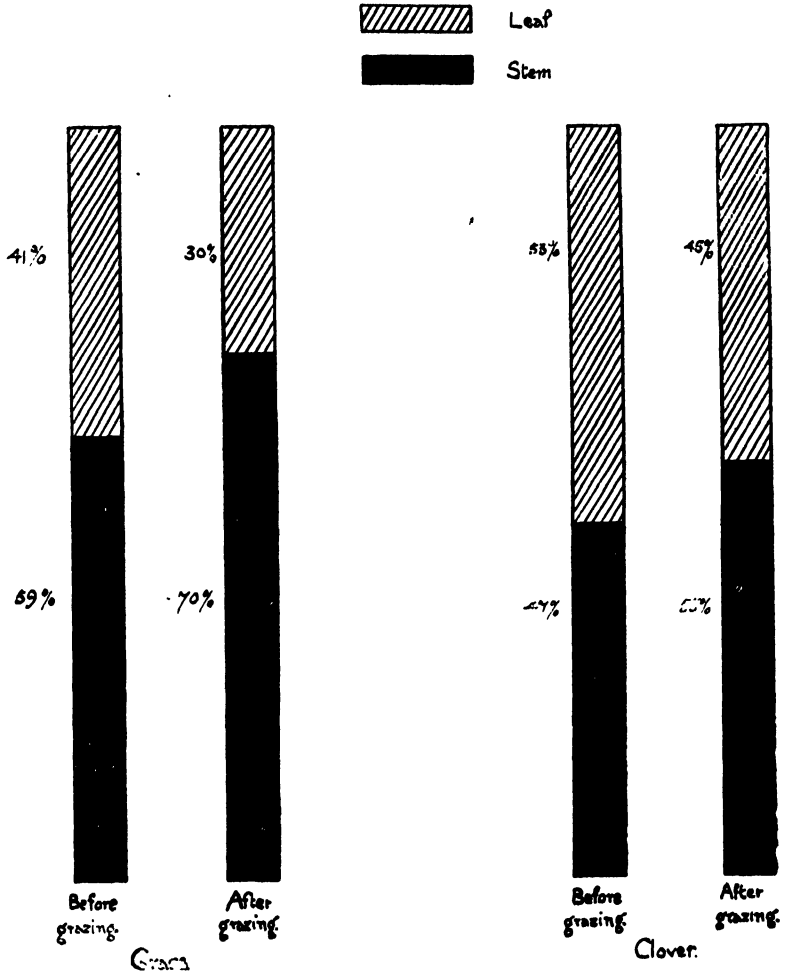
Observations on the animals when grazing suggested two reasons for this occurrence. First, the sward was more open, so that the grazing animal could the more easily and efficiently get around the plants almost individually and strip the leaves without taking the less palatable stem. In the second place, the plants in the temporary pasture had more erect tillers, and therefore their newly formed succulent leaves were more easily accessible. It

[8] Note that in a previous experiment carried out in 1926 (see Stapledon and Jones (8)) the clover was selected in preference to the grasses. It should be borne in mind that in the 1926 experiment the grasses in the temporary pasture were cocksfoot and perennial rye-grass, whereas in the present experiment the grass in the temporary pasture was Italian rye-grass, which is altogether more palatable in the young stage than either cocksfoot or perennial rye-grass.

may also be added that the ratio leaf to stem was higher on the permanent than on the temporary pasture, though as previously stated the leaf yield and the amount of leaf eaten by the sheep were higher on the temporary sward.

CHART 5.

Showing the effect of grazing on ratio of leaf to stem in temporary pasture. June 14–20, 1927.



Work in progress at the Station has shown that the operation of selective grazing continued indefinitely in a pasture has a very marked effect on the ultimate specific composition of the sward. Results of a similar nature have also been reported by Cockayne (1) in connection with his investigations in New Zealand. Constant heavy grazing weakens all plants, but the damage is

greatest in those which, apart from palatability, have the most erect habit of growth and the most rapid rate of growth. It has been shown further by Davies (2) that succulence, which to some extent is governed by rate of growth, is an important factor in connection with palatability in plants. The plants that survive in a heavily grazed pasture, therefore, are those which are best protected from being weakened either by their prostrate habit of growth or by their lack of palatability and of growth. In a mixed sward the former (habit of growth) is governed by the specific character of the individual plants in the sward. Palatability and growth are, however, the most important factors from the point of view of value of the pasture, and their operation depends to a large extent on the controlling of the grazing so as to allow the most palatable and rapidly growing plants an opportunity often enough of growing undisturbed by animals to such a size as will enable them to fortify themselves against excessive defoliation and, what is more important still, to assert themselves in the inter-specific competition for a sufficiently long time during critical periods of the season to keep in check their competitors of slower growth.

V. Discussion of Results.

It has been shown how sheep devote their time to grazing, chewing the cud, and resting in a certain periodic manner; resting during the hours of darkness, very active at dawn and at dusk, and taking about four spells of rest during the day. This periodicity is fairly similar whatever be the nature of the pasture.

The kind of pasture, however, has a marked influence on the proportion of time spent in performing each of these functions. Though no live weight increments were obtained on the rough pasture, the fact that it is rejected by sheep whenever any other pasture is available is in itself sufficient evidence to assume that it is not a good pasture, and general experience goes to show that on such a pasture animals will merely be able to maintain themselves without any increment in weight. The live weight increment obtained with the sheep, however, has shown the permanent pasture to be inferior to the temporary pasture.

In arriving at the actual nutritive value of any fodder, it should be borne in mind that the animal will consume a larger quantity of dry matter when presented in a succulent form, such as the temporary pasture, than in a less succulent form, such as permanent pasture. The relative time spent by the animals on the various pastures, however, goes to show that the more succulent the pasture, the less time is spent by the animals in

feeding—grazing and chewing the cud—and therefore the more time is available for resting. Indeed, so short was the time spent in resting by the sheep on the rough pasture, that it suggests that an animal grazing on this alone would merely be able to maintain itself, with scarcely any increment in weight.

The general agreement in the evidence derived from the period devoted to resting and that obtained relative to the live weight increment in this case suggests further that by comparison of such periods of chewing cud and of resting, a rapid method of estimating the relative value of fodders fairly similar in type could be evolved and extended to include fodders hand-fed indoors to cattle. Further investigations would be necessary in order to establish the best methods of procedure, and more knowledge is required on a number of important points.

It would be necessary to ascertain, for example, the type of animal most suitable for each particular fodder, and what age the animal should be.

In the present investigation lambs about four months old were used. These were employed in preference to mature sheep because they were smaller in size and therefore a larger number could be carried on the given small area. Another reason was their more active growth period, and hence it was considered that they would be more susceptible to the influence of the conditions—whether favourable or otherwise—and thus magnify the difference in the effect of the different pastures.

Again, for how long should it be necessary to keep the animal on a particular diet before commencing the observation, and how short a period of observation will give the necessary typical behaviour?

In this case both periods were rather short—only twenty-four hours for observation, and the observational period commenced six hours after turning in the sheep.

Another point to be considered is, How well do these artificial conditions of small folds represent the would-be behaviour and increments if the sheep were allowed a more normal area, such as a whole field with its hedges for shelter?

In this connection it may be observed that the lambs on the manured temporary pasture, though penned at the rate of twenty-six lambs per acre, gave an increment over the whole period of ten weeks at the rate of a lb. per head every 4½ days, whereas a normal store lamb at large on such a pasture would be expected to gain a lb. about every 8½ days.

Not only has the data shown the relative feeding values of the pastures over a certain period, but it has also shown how the

productivity of all the pastures falls off as the season advances, this being in agreement with the periodical productivity of the individual species contributing to the pastures (see Stapledon (5)).

This deterioration of pastures naturally raises the important question of overstocking. The application of manures at certain times will, however, assist in prolonging the high production of swards, and thus postponing the time at which overstocking is reached.

The effect of the sward on the grazing animal has been discussed at some length. The effect of the animal on the sward is quite as important, and perhaps more so, when it is borne in mind that the effect of the sward on the animal generally only lasts for one season, whereas the effect of the animal on the sward often lasts for four or five years, or in the case of land which is being laid down to a permanent sward the effect of the animal in the first year may make all the difference between a good pasture and a poor pasture for many years.

It has been shown that in a sward the plants in a stage of active growth at any particular time are greatly weakened by excessive grazing at that time. This serves to emphasise the general fact that in order to keep a certain sward productive at any period of the year, an attempt should be made to favour those plants in the inter-specific competition by exercising great care that the pasture is not overstocked at that particular period in the preceding years.

VI. Summary.

1. A sheep of about 130 lb. live weight will consume from 10 to 20 lb. of green grass per day, depending upon the succulence of the pasture. This is equivalent to 2 to 4 lb. of air-dried grass per day.
2. Under ordinary grazing conditions a sheep obtains a much higher proportion of leaf to stem, and therefore a more nutritive ration, on a temporary pasture than on a permanent pasture.
3. The live weight increment is much greater on temporary pasture than on permanent pasture, whilst the application of nitrogenous manures has to a marked extent improved both pastures in this respect, the temporary pasture showing the greater benefit as compared with the permanent pasture.
4. The live weight increment per acre deteriorated on all pastures as the season advanced (June to August), but

complete manuring, including nitrogenous fertilizers, helped to postpone this deterioration.

5. The temporary pasture suffered more than the permanent pasture from overstocking.
6. The time spent by an animal in chewing the cud and in resting on any particular pasture would appear to give a useful indication of the nutritive value of that pasture, the more time spent in resting, and the less time in grazing, and particularly in chewing the cud, indicating a good pasture. Lambs spent far more time resting on a temporary ley than on a piece of rough permanent sward.
7. The time of the year and the intensity of grazing largely govern the composition of the sward, while the effect of the management of one year on the composition of the sward the next year is a function of intensity of grazing in relation to the various seasons of the year.

Acknowledgments.

The writer desires to express his thanks to Professor R. G. Stapledon for his helpful interest in the investigations here dealt with, and for valuable suggestions as to the best means of conducting the experiment. Thanks are also due to Mr. William Davies, M.Sc., for assistance relative to certain aspects of the work described. Grateful acknowledgment is made to Mr. J. W. Watkins, Superintendent of the Farm and Gardens, for taking a share of the night watches relative to the continuous observations on the sheep. The remaining watches were kept by senior men at the Farm during the night, and by the technical assistants during the day, to all of whom thanks are due.

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THE BEHAVIOUR OF GRASSES IN THE SEEDING YEAR, WHEN SOWN IN PURE PLOTS: ESTABLISHMENT, RATE OF GROWTH AND PALATABILITY.

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Introduction.

Previous experiments conducted at the Welsh Plant Breeding Station under normal field conditions with herbage plants have, in the main, dealt with the behaviour of these species during the first and subsequent harvest years. The present paper is concerned entirely with the agronomic peculiarities of a number of species during the first six months after sowing. The rapidity of development from seed during the year of sowing under sward conditions has been critically studied. This aspect of the problem is important with a view to placing the species and strains in their correct perspective in relation to competition, and therefore as affecting ultimate sward development. It is likely that a species which establishes itself well and develops quickly to maturity is an aggressor in competition with a more slowly growing type, which latter, however, if allowed a fair chance may become of fundamental importance to the productivity of the ley after the first year.

Material and Methods.

Ninety-five single species plots were sown (broadcast) on the Cwm Field of the Welsh Plant Breeding Station Farm on May 7th, 1927, without a cereal or other nurse crop. The plots were generally 1/100th acre, but in the case of certain of the pedigree wild strains, owing to shortage of seed, 1/400th acre

plots were employed. Thirty strains belonging to twelve species were under test and wherever possible the plots were replicated four times. Table I gives details of the seed sown, the size of plot and the number of replications.

Basic slag was applied to the field in 1924 at the rate of 6 cwt. per acre. Plots of red clover were laid out in that year, the area was reploughed in 1925, and fallowed and limed in 1926.

TABLE I.

Showing details of seeding: strain, rate of sowing, size and replication of plots.

E 73. V. 1927

Species.	*Station number.*	*Strain.*	*Lb. per acre.*	*Size of plot and replications.*
Perennial rye-grass (*Lolium perenne*)	Ba 1413	Indigenous	25	1/400th acre x 3
,,	Ba 1767	Wild (ex Kent)	25	1/100th acre x 4
,,	Ba 1756	N.Z. Sandon	25	1/100th acre x 4
,,	Ba 1768	Commercial	25	1/100th acre x 3
,,	Ba 1775	N.Z.	30	1/100th acre x 4
Italian rye-grass	Bb 182	Commercial	30	1/100th acre x 4
Cocksfoot (*Dactylis glomerata*)	Bc 1163	Indigenous	25	1/100th acre x 4
,,	Bc 1162	Indigenous	25	1/100th acre x 3
,,	Bc 1645	Commercial	25	1/100th acre x 3
,,	Bc 1629	Indigenous	25	1/400th acre x 2
,,	Bc 1650	N.Z.	30	1/100th acre x 3
Timothy (*Phleum pratense*)	Bd 309	Indigenous	15	1/100th acre x 4
,,	Bd 310	Indigenous	15	1/400th acre x 3
,,	Bd 326	Indigenous	15	1/400th acre x 3
,,	Bd 362	Commercial	15	1/100th acre x 4
Crested dogstail (*Cynosurus cristatus*)	Bg 322	Wild Kent	15	1/100th acre x 4
Meadow foxtail (*Alopecurus pratensis*)	Bh 284	Indigenous	25	1/100th acre x 4
,,	Bh 379	Commercial	25	1/100th acre x 3
Red fescue (*Festuca rubra*)	Bl 728	Indigenous	20	1/400th acre x 3
Chewing's fescue (*Festuca rubra var.*)	Bl 921	Commercial	20	1/100th acre x 3
Sheep's fescue (*Festuca ovina*)	Bl 727	Indigenous	20	1/100th acre x 3
Golden oat grass (*Trisetum flavescens*)	Bs 283	Commercial	20	1/100th acre x 3
Yorkshire fog (*Holcus lanatus*)	Bs 370	Commercial	25	1/100th acre x 3
Red top (*Agrostis spp.*)	Br 44	American	30	1/100th acre x 3
Brown top (*Agrostis spp.*)	Br 50	N.Z.	30	1/100th acre x 3
Bromus arvensis	Bs 369	Commercial	30	1/100th acre x 3
Bird's foot trefoil (*Lotus corniculatus*)	Al 8	Commercial	10	1/100th acre x 3
,,	Al 11	Wild	10	1/100th acre x 3
(*Lotus major*)	Al 10	Commercial	10	1/100th acre x 2
,,	Al 9	Commercial	10	1/100th acre x 2

The plots were under critical observation from the outset, comparative notes being taken at regular intervals. Counts of established seedlings were made on all plots on July 8th (sixty-two days after sowing); a further count was made on most of the plots on August 26th (111 days after sowing), and yet another in early October, when the experiment was about twenty weeks old. The method of analysis was that normally adopted at the Station, the number of seedlings found within a square mesh (6 inches x 6 inches) were counted, ten readings being taken at each count.

Tiller counts were made at frequent intervals on one series of plots only: ten plants were lifted at random on each plot at the several dates, and the average number of tillers per plant was estimated.

All the plots were grazed by the Station flock of Kerry Hill and Suffolk sheep in early August, and again in early October. At each grazing period frequent and detailed observations were made as to the relative palatability of the species and strains under review. Before each of the two grazing periods, samples were taken in order to estimate by weight the relative growth of the various species. These samples were air-dried in scrim bags, and the weight of air-dried produce was calculated. A second sample was taken for botanical analysis by cutting ten or more handfuls at random over each plot; by this means the percentage of sown species and weeds was estimated. Marks on a scale of 0-10 were made at intervals on the plots in respect of relative total growth of the sown species, and these data were supplemented by those obtained from actual quantitative samples taken before grazing.

Discussion of Results.

1. *Seedling establishment and summer casualties.*

Results obtained from previous experiments on the percentage establishment of the common herbage plants and already reported upon by Davies (1) have indicated that under normal field conditions only a proportion of the viable seed sown is successful in the production of seedlings as found in the autumn of the year of sowing. It has also been shown that the casualties from the seeding year to the first harvest year are considerable. The present experiment deals with the loss in number of seedlings during the summer following seeding. The data in regard to establishment have been drawn up in Table II, and these show that in many cases the casualties during the first few months after sowing are heavy among the already germinated seedlings.

It is indicated, however, that the loss is not proportional in all species or in all strains within the species—the total loss is usually more pronounced in the commercial strains, being often quite small in the indigenous lots. In general, commercial " seed " germinates more rapidly than the indigenous strains, having on the average larger and better devoloped endosperm than in the case of that harvested at Aberystwyth; the number of established seedlings per 100 seed sown is usually higher than in the indigenous lots. There is good reason for believing, however, that delayed germination, although probably a factor having considerable influence upon establishment in most herbage plants, is especially important in the case of the smaller seeded indigenous strains.

It also seems likely that species which are potentially capable of rapid establishment suffer from a minimum of delayed germination, and quick seedling development follows, but on account of the keener competition set up among the young plants they tend to have a larger percentage of summer casualties than the species of slow early growth. These considerations apply more particularly to the comparison of pure culture beds sown without a nurse crop, and the phenomenon is most marked when the early growth is allowed to accumulate. On *a priori* reasoning inter-plant competition in pure beds begins earliest and is keenest in species that develop most rapidly from seed. The results in Table II show that Italian rye-grass and perennial rye-grass each suffer very heavily from summer killing of plants; both species have been shown by Stapledon and his co-workers (7) to germinate quickly and to develop into strong seedlings. The fine-leaved fescues on the other hand are slow to establish themselves, but the present results show they retain their initial establishment. Similarly in a comparison of indigenous and commercial strains within the same species it is seen that the former, although not having so good an early establishment, are better able to keep up their numbers than are the latter. Further, the results indicate that there remain a considerable number of seed that do not germinate readily in the soil, and that their germination may be delayed for some time and until sub-aerial conditions become more favourable to their growth. This state of affairs is reflected by the data in Table II, where many of the indigenous lots show an increased number of plants in the count made in October, 1927, as compared with the second or August counts. The second count was made directly after a grazing period prior to which there was an accumulation of foggage produced during May to August, which on some of the plots

TABLE II.

To show the per cent. establishment of viable seed in respect of a number of herbage plants at three dates during the seeding year 1927. E 73. V. Sown May 7th, 1927.

	Station No.	*Percentage establishment, July 8th.*	*Percentage establishment, Aug. 26th.*	*Percentage establishment, Oct. 11th.*
Perennial rye-grass (Indigenous)	Ba 1413	32·9	18·6	23·8
Perennial rye-grass (Indigenous)	Ba 1767	60·0	33·0	34·1
Perennial rye-grass (New Zealand)	Ba 1756	52·7	25·5	20·8
Italian rye-grass (Commercial)	Bb 182	51·5	32·4	22·4
Cocksfoot (Indigenous)	Bc 1163	32·0	17·8	14·8
Cocksfoot (Indigenous)	Bc 1162	24·3	17·3	8·1
Cocksfoot (Indigenous)	Bc 1629	24·0	17·4	30·2
Cocksfoot (Commercial)	Bc 1645	39·0	19·2	15·4
Cocksfoot (New Zealand)	Bc 1650	27·5	18·4	20·5
Timothy (Indigenous)	Bd 309	23·4	11·4	10·0
Timothy (Indigenous)	Bd 310	21·4	10·4	22·2
Timothy (Commercial)	Bd 362	29·4	13·3	13·1
Average of above 12 species and strains	—	34·8	19·6	19·6
Crested dogstail (Wild Kent)	Bg 322	38·6	—	16·1
Meadow foxtail (Indigenous)	Bh 284	39·4	—	21·4
Meadow foxtail (Commercial)	Bh 379	19·5	—	9·7
Fine-leaved fescue (Commercial)	Bl 921	35·3	—	33·2
Fine-leaved fescue (Indigenous)	Bl 728	47·1	—	46·6
Fine-leaved fescue (Indigenous)	Bl 727	24·0	—	16·8
Golden oat grass (Commercial)	Bs 233	19·8	—	11·8
Yorkshire fog (Commercial)	Bs 370	34·3	—	21·7
Agrostis species (American)	Br 44	6·3	—	2·8
Bromus arvensis (Commercial)	Bs 369	52·3	—	35·3
Average of above 22 species and strains	—	33·4	—	20·5
Timothy (Indigenous)	Bd 326	29·7	16·8	—*
Agrostis species (New Zealand)	Br 50	10·3	—	—*

* Bottom growth too dense to allow of accurate counts.

more or less successfully prevented light and air penetrating the surface soil. There would, therefore, appear to be a physiological reaction between the seed and its external requirements of light and of air for germination. Delayed germination thus tends to be due in part to the inability of a certain proportion of the seed to germinate quickly after sowing; seeds which are able to germinate readily give rise to seedlings which after a few weeks of growth and in the aggregate keep the surface soil in more or less shade conditions, and this possibly effects a further delay in the germination of hitherto quiescent seed. When the accumulated growth is removed by grazing, or by the mowing machine, light and air are able to circulate more freely in the surface soil and give an impetus to the germination of as yet dormant seed. Competition in the young sward during the pre-grazing period, therefore, tends to lower the number of plants by killing off the weaker among them, and at the same time increases the tendency to delay germination. Consequent upon grazing, soil conditions more amenable to good germination are produced, and any dormant seeds may give rise to a further crop of established seedlings. Competition during the following period is never so intense as during early summer.

The aggregate establishment for all species in the present experiment indicates a marked decline in the number of seedlings enumerated as from the first count (sixty-two days) to the second count (111 days) after sowing, and a further small decline at the October count (twenty weeks). There is thus every indication to suggest that the competitive interaction set up during the first three months caused, in most species, a larger reduction in the number of seedlings than the phenomenon of delayed germination could later repair.

These suggestions are tentatively made to explain the results under review; results which, however, are typical of both critical and observational data obtained on the problems under study at the Station.

From a purely economic standpoint the results clearly indicate that in wetter districts at least young " seeds " laid out without a nurse crop should be grazed quite early in the season, as by this means the surface soil is better aerated and receives more direct light, conditions which make for better and quicker germination of the more slowly developing " seeds "; furthermore, if sheep are grazed on the young pasture they consolidate the surface layers, soil, seeds and roots being pressed into closer contact and giving a better chance of establishment of any weak seedlings in the sward complex. These conclusions derive

marked support from the interesting practical experiences of Hosier (8) in Wiltshire.

2. *Rate of growth in the seeding year.*

Comparative marks on a basis of 0-10 were given for growth on the various plots at intervals throughout the summer. The growth of the several species is contrasted in Table III, Italian rye-grass at each date having been placed at 100 and the other species relatively.

TABLE III.

To show the relative growth rates during the seeding year of certain grasses and clovers.

Italian rye-grass = 100 at each date. E 73. V. 1927.

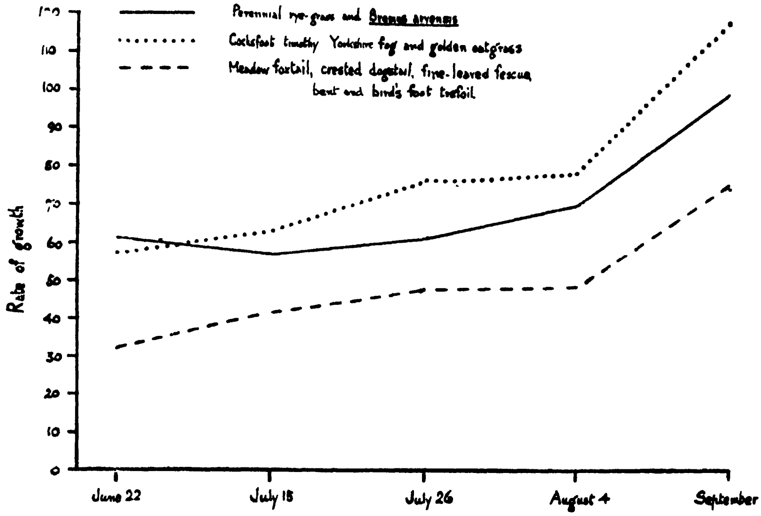
Species.	*June 27th*	*July 15th*	*July 26th*	*Aug. 4th*	*Oct. 3rd.*
Italian rye-grass (Commercial)	100	100	100	100	100
Perennial rye-grass (Indigenous)	59	49	62	70	107
,, ,, (Commercial)	69	51	61	69	78
,, ,, (New Zealand)	61	56	48	66	119
Cocksfoot (Indigenous)	44	42	56	61	117
,, (Commercial)	79	83	85	87	140
,, (New Zealand)	50	49	64	66	120
Timothy (Indigenous)	47	47	77	93	85
,, (Commercial)	64	97	103	98	139
Crested dogstail (Wild Kent)	25	34	53	52	66
Meadow foxtail (Indigenous)	50	57	69	75	122
,, ,, (Commercial)	46	42	50	55	59
Fine-leaved fescue (Indigenous)	38	51	48	52	83
,, ,, (Commercial)	25	46	41	44	85
Golden oat grass (Commercial)	50	57	69	64	107
Yorkshire fog (Commercial)	63	69	78	83	127
Bromus arvensis (Commercial)	67	72	74	74	94
Agrostis species ...	24	38	39	30	82
Bird's foot trefoil ...	19	18	38	32	34
Average of all species excluding Italian rye-grass ...	49	53	62	65	98

It will readily be seen that there is marked variation in the rate of early productivity in the several species and strains. The data for perennial rye-grass, cocksfoot and timothy afford clear evidence that the commercial lots start off much more quickly from seed than do their indigenous counterparts. In most cases, however, the difference in total growth as between strains within the species was gradually lessened after the first two months, until by October, and even August in some cases, the difference was negligible; indigenous perennial rye-grass in the present instance surpassed commercial in productivity as early as July 26th, retaining that position at the later observations. It is significant in view of the findings of Stapledon (5) to-

note that New Zealand cocksfoot approaches more closely to our indigenous stocks than it does to the commercial. Among the slower developing species, meadow foxtail and the fine-leaved fescues, in particular the commercial lots, do not hold an initial advantage over the pedigree stocks, indeed, commercial foxtail has at no date made growth equivalent to that of the indigenous strain.

FIG. 1.

To show growth rate of different species during the seeding year.
Italian rye-grass at 100 in all cases. **E 73. V. 1927.**



Crested dogstail, *Agrostis* species and bird's foot trefoil are each shown to make slow early growth, whereas *Bromus arvensis*, golden oat grass and Yorkshire fog can in this respect be classed with perennial rye-grass and cocksfoot. Fig. 1 is of interest in comparing the relative seeding year productivity of the various species under test. In all cases Italian rye-grass is placed at 100, and for clearness the other species have been grouped as hereunder, and the averages taken at any one date of observation :—

Species of fairly rapid early growth—Perennial rye-grass, *Bromus arvensis*.
Species of medium early growth—Cocksfoot, timothy, Yorkshire fog and golden oat grass.
Species of slow early growth—Meadow foxtail, crested dogstail, fine-leaved fescues, bent and bird's foot trefoil.

It will be seen that on June 22nd, six weeks after sowing, Italian rye-grass had made much heavier growth than the best of the other species, but this initial gain gradually diminished as the summer advanced. By the beginning of October, all but the species of small seeding year productivity were outyielding

Italian rye-grass. A similar result was obtained in garden trials already reported by Stapledon and others (7). In any study of the competition complex as it affects temporary swards it is clear that the data now presented are of the utmost importance. If a seeds mixture be sown containing plants representative of groups of potentially different growth rates from seed it is evident that species of rapid early development will tend, if allowed to grow unchecked, to delay the development of the slower growing species. When competition becomes severe and prolonged there is likely to be an actual elimination of the weaker plants, the majority of which belong to species of slow initial growth albeit of greater persistency, and designed as the basis of productivity during the later harvest years.

3. *Tiller production in the seeding year.*

Table IV shows the tendency to increase in tillering as the plant becomes older, which is apparent in all species when grown in pure culture broadcast plots. A comparison of the average tillering capacity of each species is interesting and shows that, as in the Aberystwyth garden trials already reported on by Stapledon (6), the fine-leaved fescues appear to have a high tillering capacity.

TABLE IV.

To show the tiller production per plant at four dates during the seeding year in certain species of herbage plants.

E 73. V. 1927.

Species.	*June 27th*	*July 18th*	*Aug. 4th*	*Oct. 3rd*	*Average.*
Perennial rye-grass ...	3·5	3·9	4·1	4·7	4·1
Italian rye-grass ...	2·5	3·1	3·8	3·4	3·2
Cocksfoot ...	2·2	2·4	3·2	3·7	2·9
Timothy ...	1·4	2·4	2·5	3·0	2·3
Meadow foxtail ...	3·1	3·0	3·0	3·6	3·2
Fine-leaved fescue ...	4·9	7·4	6·3	4·7	5·9
Crested dogstail ...	1·0	1·5	2·0	2·5	1·8
Agrostis species ...	1·5	1·1	1·1	3·1	1·7
Bromus arvensis ...	4·4	2·5	4·9	6·3	4·5
Yorkshire fog ...	3·9	2·6	2·1	4·6	3·3
Golden oat grass ...	1·6	2·0	2·8	2·4	2·2
Average of all species ...	2·7	2·9	3·3	3·8	—

Bromus arvensis and Yorkshire fog, two species hitherto not under extensive trial at the Station, show to advantage in respect of high tillering capacity. Perennial rye-grass tillers better than Italian rye-grass, whilst seeding year development in cocksfoot, timothy. crested dogstail and bent species is considerably poorer.

All the tests so far made at the Station have demonstrated that the indigenous strains tiller more abundantly than the commercial stocks. The following statement based on the experiment now under reivew and in respect of average tillers per plant supports the conclusions already arrived at in the garden trials conducted by Stapledon (6).

	Indigenous.	*Commercial.*
Perennial rye-grass ...	4·2 ...	3·8
Cocksfoot	3·3 ...	2·2
Timothy	2·8 ...	1·8
Meadow foxtail	3·1 ...	3·2

4. *Palatability to sheep during the seeding year.*

The question of the palatability of the common herbage plants has been under critical study at the Station, and a report dealing with plants in the first harvest year has already been published by Davies (2). The present section deals with the palatability of some species during the seeding year. Previously all tests have shown that leaf is more palatable to stock than stem, and since herbage plants are, in the main, preponderantly leafy during the seeding year, it follows that selective grazing at this period is not so apparent as it is during the summer of the first harvest year. It has been evident, however, that sheep do select plants of one species in preference to those of another during the seeding year. The average results in the present instance have been summarized in Table V, Italian rye-grass for this purpose being placed at 100.

TABLE V.

To show the relative palatability of certain grasses during the seeding year. Four observations at each of the two grazing periods. (August and October).

Italian rye-grass = 100 in all cases. **E 73. V. 1927.**

	Average for species.				
Species.	*1st Observ.*	*2nd Observ.*	*3rd Observ.*	*4th Observ.*	*Average.*
Italian rye-grass ...	100	100	100	100	100
Perennial rye-grass ...	13	38	43	55	37
Cocksfoot ...	0	11	21	44	19
Timothy ...	7	49	51	57	41
Crested dogstail ...	12	55	55	65	47
Meadow foxtail ...	2	18	21	34	19
Fine-leaved fescue ...	3	12	5	21	10
Golden oat grass ...	0	6	12	15	8
Yorkshire fog ...	16	36	39	51	36
Agrostis species ...	0	21	23	36	20
Bromus arvensis ...	28	66	74	69	59
Average of all species, excepting Italian rye-grass ...	8	31	34	45	

It is perhaps surprising to find that Yorkshire fog during its early growth stages is as palatable as timothy, cocksfoot, perennial rye-grass and meadow foxtail, typical representatives of the so-called superior grasses. Previous observations have indicated that Yorkshire fog, if correctly grazed, may provide a considerable amount of valuable keep, and the results indicate that the bad reputation that fog has earned in the popular as well as in the scientific mind is due, in part at least, to improper management of pastures containing this grass. The productivity figures already discussed have shown that fog is capable of rapid growth; it is certainly a species that can recover quickly after defoliation, and for this reason soon becomes unpalatable in comparison with other species. This grass may have a higher potential value than is at present popularly assumed, and more detailed knowledge is desirable in regard to its management as a grazing plant. The point is important since *Holcus* is one of the most aggressive species, as well as one highly productive of leaf under pasture conditions over a large area of Britain, and its value under a correct system of management relative to other species may, therefore, repay detailed investigation. Chemical analyses conducted by Fagan (3) have shown that Yorkshire fog compares favourably with other species in regard to nutritive value of both leaf and stem. Agronomically Yorkshire fog behaves in many ways like Cocksfoot; rapid recovery after grazing, for example, is common to both. Normally fog is more winter green than commercial cocksfoot, and it is reasonable to hope that the plant breeder may be able to evolve strains of fog characterized by resistance to burn and to " rust " attack.

Returning to Table V, the relatively low seeding year palatability of cocksfoot, *Agrostis* and meadow foxtail is noteworthy, whilst golden oat grass and the fine-leaved fescues are strikingly unpalatable when other species are available. The figures for cocksfoot, however, call for explanation; this species winter burns during September, and in consequence the palatability results for the October grazing period are very low in comparison with those obtained in August. The following statement gives comparative figures for the last observation made at each grazing period in respect of cocksfoot, with Italian rye-grass at 100; the relative figures (October) for " burn " are also given to compare indigenous and New Zealand cocksfoot on the one hand with Danish cocksfoot (put at 100) on the other.

Last observations (taken after sheep were turned off plots).

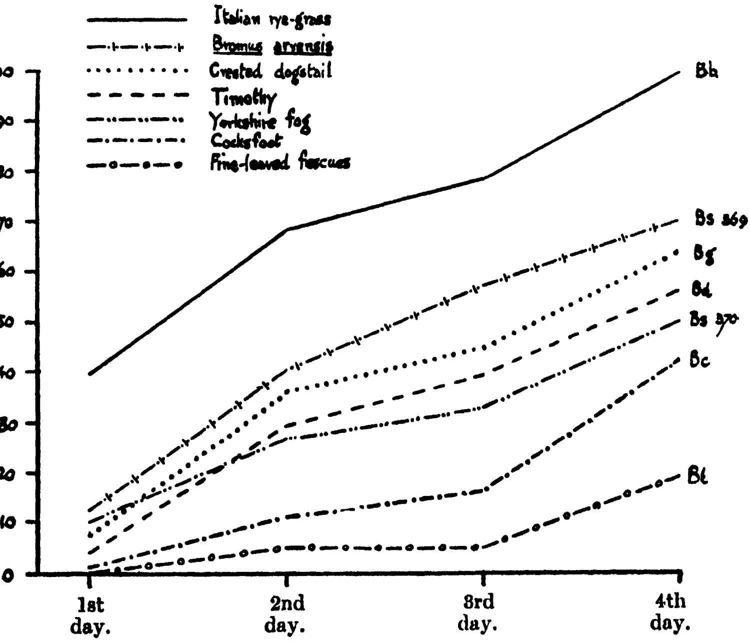
	August.	*October.*	*" Burn " (October).*
Cocksfoot (Indigenous and New Zealand)	71	35	32
Cocksfoot (Danish)	64	15	100

The statement is important in that it shows that palatability during the autumn months is to a large measure influenced by the degree of leaf " burn ". The Danish commercial strain was badly " burned " in October and therefore was not relished by stock. Indigenous strains on the other hand remained more winter green and were therefore more readily selected by the grazing animal. It is noteworthy that cocksfoot as a whole assumed a fairly high palatability in relation to other species during August.

Observations on palatability were made during four consecutive days at two separate periods, and the data obtained have been averaged to show the successive daily readings for the two periods taken together. The results are shown in Fig. 2. The fourth day's data in respect of Italian rye-grass is placed at 100.[1]

FIG. 2.

To show the relative amount eaten of a number of species at four consecutive daily observations. Average of the two periods, August and October. E 73. V. 1927.



The figure demonstrates that of the species included in the trial, Italian rye-grass was the most palatable at all times, but that as keep became shorter on the plots, as it was bound to do

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1 Practically all the Italian rye-grass available having been eaten by the end of the fourth day.

when the grazing period was lengthened, other species approached much more closely to it in palatability. Golden oat grass and the fine-leaved fescues were, however, more or less neglected at all times, although their curve also shows an upward tendency.

5. " *Burn* ".

Observations on autumn browning indicate that of the strains under test commercial cocksfoot was the first to show " burn ". Even up to mid-October there was relatively little leaf burn in the indigenous stocks of cocksfoot. Commercial meadow foxtail was very badly attacked by leaf rust, as already reported by Sampson (4) in connection with earlier trials, whilst the more rust resistant indigenous strain was only slightly affected. " Rust " in foxtail produces a condition analogous to " burn ", the rusted plants becoming very unpalatable to sheep. The New Zealand brown top (*Agrostis* species) was considerably leaf burned by mid-September—these plots had then the appearance typical of many of our Welsh pastures after deterioration has commenced. Plants of *Bromus arvensis* developed a red colouration in the leafage during the early autumn, but this did not appear to affect its palatability. Italian rye-grass, crested dogstail, golden oat grass, timothy, Yorkshire fog and perennial rye-grass all remained quite green, but there were signs that rust attack (*Puccinia lolii*) had begun on the two last named species. Indigenous fine-leaved fescue remained quite green, whilst the plots of Chewing's fescue had browned considerably. These observations, although confined to the seeding year growth, confirm results already reported by Stapledon and Davies (6) in respect to winter " burn " on older swards.

General Notes on the behaviour of Species in the Seeding Year.

Italian rye-grass is potentially capable of good and very rapid establishment from seed, affording valuable grazing, almost wholly comprised of leafage, during the seeding year. Its rapidity of recovery after defoliation makes it an invaluable pasture grass for short term leys. It remains winter green and is capable of making an important contribution to autumn and winter keep.

Perennial rye-grass is able to establish itself well from seed, but does not make such rapid growth as Italian rye-grass; partly for this reason it is less palatable than the latter under normal sward conditions. It is able to recover quickly after grazing. The indigenous strains tiller better than the commercial and, therefore, tend to form a denser sward. There does not appear

to be any great difference between ordinary commercial perennial rye-grass and that from New Zealand—on the whole the English rye-grass of commerce is the better of the two. Wild stocks harvested from old Kentish swards more nearly approach the pedigree (indigenous) stocks than do either commercial or New Zealand strains.

Cocksfoot does not establish so well nor so rapidly from seed as do the rye-grasses. Once established, it is able to make quick recovery after grazing. The indigenous lots surpass the normal Danish variety in respect of palatability, tiller production and winter greenness. During the seeding year, however, the commercial strain has outyielded the best of the indigenous, showing that the latter do not make such rapid early development.

Timothy, with regard to establishment from seed, is poor in comparison with the rye-grasses, and, moreover, does not develop rapidly during the first season. Commercial timothy when sown alone runs to head in a few weeks after brairding, but there is no such tendency in the pedigree types, which are superior also in respect of tiller production and density of sward. Timothy is one of the most highly palatable species during its early growth stages, but its relative position in this respect is not so high during the later season; this is particularly marked in the commercial strains in which leaf growth practically ceases after the end of August.

Crested dogstail—considering the relatively small size of its seed—is able to establish itself well under ordinary field conditions. Its early development is very slow, and its tiller production poor. The leafage is highly palatable, and remains wonderfully wintergreen. During the seeding year it shows no tendency to stem production.

Meadow foxtail is characterised by low establishment and its early productivity is poor. The leafage is never highly palatable, but during the autumn it becomes comparatively unpalatable, especially in the Finnish strain (commercial) most susceptible to rust. The best indigenous types are of considerably better establishment and more productive of leafage during the seeding year; they are also more resistant to disease attack, although not entirely immune. There is little, if any, attempt at panicle production in the year of sowing.

Fine-leaved fescues show poor initial establishment from seed and the total productivity in the seeding year is very low. No panicles are produced during this period, but the leafage is at no time relished by stock. Tiller production is abundant, and the resulting sward is fairly dense. Selected, indigenous stocks

give rise to plants that are considerably more winter green than the New Zealand strain (Chewing's), but they are not marked by an improvement in either rapidity of seeding year growth or in palatability.

Golden oat grass gives very poor establishment, but makes fairly good growth during the seeding year. Panicle production starts within a few weeks of brairding, with the result that golden oat grass stands as one of the most unpalatable species under test during the period reviewed. This grass remains fairly green during the early autumn, but tends to " burn " later in the season.

Agrostis species were among the poorest to establish from seed, as was to be expected from a consideration of their grain weight. American red top (a variety of *Agrostis alba*) was particularly poor in establishment, and as a result the data in respect of growth and palatability for this variety lack significance in the present trials. New Zealand brown top (said to be a form of *Agrostis vulgaris*) established rather better, but in both cases early growth was very small. By the autumn, the latter had given rise to a dense sward of relatively unpalatable herbage; even in mid-September the plots had all the appearance of a long established but badly neglected bent pasture.

Yorkshire fog shows very good initial establishment which is followed by a rapid seeding year growth of leafy herbage; this is palatable to sheep unless allowed to become too advanced in growth. It tillers well, and at the rate of seeding adopted in the present experiment formed a fairly dense sward within a few weeks of sowing; it remains fairly green well into the autumn. There is no tendency to panicle production during the seeding year.

Bromus arvensis gives good establishment from seed, tillers well, and quickly forms a dense sward. Its early growth is rapid, and the produce, which is wholly leafage, is very palatable. As a constituent for short term leys it deserves wider attention than it has received heretofore in this country.

Lotus species. Four strains of *Lotus corniculatus* and of *Lotus major* were tested in these trials. All the lots gave poor soil establishment, and made very slow early growth as compared with the grasses. The herbage, however, was extremely palatable to sheep during August, but the power of recovery after grazing was poor. It may be advantageous under these circumstances to sow *Lotus* with Italian rye-grass; the latter would act as nurse to the weaker *Lotus* seedlings and would ensure their not being too heavily grazed during the seeding year. This

aspect of the potential value of Italian rye-grass is one applicable to all slowly developing, albeit highly palatable, species.

Summary.

1. The behaviour during the seeding year of a number of species and strains of herbage plants has been discussed.
2. It has been demonstrated that under normal sward conditions in the field there are wide differences in the agronomic behaviour of the species in the year of sowing, such as relative establishment, rate of early development, tiller production, palatability and winter greenness.
3. Italian rye-grass is the species of outstanding potentialities during the early growth periods; potentialities which mark it as an important plant during this period.
4. Attention has been drawn to the possibilities of closer investigation into the real economic value of species such as Yorkshire fog (*Holcus lanatus*) and *Bromus arvensis;* it is felt that fog in particular needs to be placed in its proper perspective in relation to what are popularly described as valuable grasses.

For assistance in analytical work on this experiment acknowledgment is due to the following students of the Agricultural Department of the College—Dr. J. G. Davies, Messrs. Ll. I. Jones, B.Sc., I. G. Lewis, and K. Ø. Pedersen.

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AN INVESTIGATION INTO THE SOIL GERMINATION AND YIELD OF CERTAIN CRUCIFERS, CLOVERS, ITALIAN RYE-GRASS AND CHICORY SOWN AT THREE-WEEKLY INTERVALS FROM MAY TO NOVEMBER, 1925.

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In view of the fact that certain crucifers and chicory are not uncommonly sown with seeds mixtures it seemed desirable to conduct an experiment with some of the plants on lines very similar to trials with grasses and clovers, the results of which have appeared in a recent bulletin[1], and to which frequent reference will be made in this article.

The experiment (E.48,IV) consisted in sowing the species under consideration at three-weekly intervals from early May to early November of 1925. Ten sowings were made, the dates of sowing being as follows :—May 9th, May 29th, June 22nd, July 10th, July 31st, August 21st, September 11th, October 2nd, October 23rd, and November 13th. All the sowings were made on similarly prepared tilths on the Terraces of the Plant Breeding Station Gardens, the covering and after-treatment of the seed beds being similar in each case.

The species included in the experiment were as follows :—mustard, rape, six weeks, green top and hardy green turnips, kohl-rabi, thousand-headed, marrow-stem, Scotch, cottagers and rape kales, Brussels sprouts, sprouting broccoli, chicory, Italian rye-grass, and broad red and subterranean clovers. The Italian rye-grass and clovers were included for purposes of comparison. All the species were sown at the same rate of seeding, namely, five viable seeds per linear inch and therefore 300 viable seeds per five feet row.

I. Soil Germination.

An endeavour has been made to consider the soil germination of the species in connection with the climatic conditions that existed after each sowing. The meteorological data used in this connection were rainfall, accumulated temperature (average of maximum and minimum temperatures minus 42°F.) and ground frost. These data have been worked out for four weeks following the date of each sowing in order to cover a period sufficient for all the viable seeds to germinate. The results are given in Tables

[1] Welsh Plant Breeding Station Bulletin, Series H, No. 6, May, 1927.

I, II and III. The percentage of soil germination recorded for each species for each of the ten sowings is given in Table IV. The average soil germination for the ten sowings and the laboratory germination are also given for each species.

First sowing, May 9th.

The weather conditions for a two-week period previous to this date are shown by the following statement :—

	Rainfall.	*Accumulated temperature.*
April 25th—May 1st	0·177	12°F
May 2nd—May 9th	0·900	33°F

It will be seen on reference to Tables I and II that the rainfall for the four weeks following sowing was 3.24 inches and the accumulated temperature 278°F. The majority of the rain fell during the second and third weeks. The rainfall was favourable for soil germination, as the soil was moist when sowing was carried out and remained in this condition for some considerable time following the date of sowing.

The temperature rose steadily from the first to the third week following sowing.

TABLE I.

Rainfall for the four weeks following each sowing with the totals for the four weeks.

Date of sowing.	*First week. Ins.*	*Second week. Ins.*	*Third week. Ins.*	*Fourth week. Ins.*	*Total for 4 weeks. Ins.*
First sowing. May 9th.	0·401	1·216	1·507	0·116	3·240
Second sowing. May 29th.	0·399	0·000	0·059	0·010	0·468
Third sowing. June 22nd.	0·010	0·157	0·701	0·451	1·319
Fourth sowing. July 10th.	0·182	0·384	1·958	1·467	3·991
Fifth sowing. July 31st.	1·467	1·630	0·426	0·876	4·399
Sixth sowing. August 21st.	0·876	0·509	1·344	0·354	3·083
Seventh sowing. September 11th.	0·354	2·137	0·411	0·048	2·950
Eighth sowing. October 2nd.	0·048	0·671	1·966	1·601	4·286
Ninth sowing. October 23rd.	1·601	0·981	0·673	0·000	3·255
Tenth sowing. November 13th.	0·000	0·206	0·525	0·550	1·281

TABLE II.

Accumulated temperature for the four weeks following each sowing with the total for the four weeks in degrees Fahr.

Date of sowing.	*First week.*	*Second week.*	*Third week.*	*Fourth week.*	*Total for 4 weeks.*
First sowing. May 9th.	59	66	79	74	278
Second sowing. May 29th.	68	162	104	76	410
Third sowing. June 22nd.	76	123	107	120	426
Fourth sowing. July 10th.	121	153	115	105	494
Fifth sowing. July 31st.	105	119	124	101	449
Sixth sowing. August 21st.	101	103	70	72	346
Seventh sowing. September 11th.	72	67	80	80	299
Eighth sowing. October 2nd.	80	23	70	65	238
Ninth sowing. October 23rd.	65	64	14	0	143
Tenth sowing. November 13th.	0	1	0	10	11

TABLE III.

Number of days in each week for four weeks following the eighth, ninth and tenth sowings on which ground frost was registered.

Sowing.	*First week.*	*Second week.*	*Third week.*	*Fourth week.*
Eighth	–	5	–	–
Ninth	–	–	4	6
Tenth	7	7	7	3

Reference to Table IV will show that the average soil germination for all the species was 55.0 per cent. for this sowing, while the average for the crucifers alone was slightly higher. It will be noted that the soil germinations of the species are very variable, ranging, with the exception of green top turnip, from 19.6 per cent. for chicory to 76.8 per cent. for Italian rye-grass.

TABLE IV.

Percentage soil germination of the viable seed of the species for each sowing, the average for the ten sowings, and laboratory germination for each species.

Species.	Laboratory Germinations.	Dates of Sowing.										Average.
		May 9th.	*May 29th.*	*June 22nd.*	*July 10th.*	*July 31st.*	*Aug. 21st.*	*Sept. 11th.*	*Oct. 2nd.*	*Oct. 23rd.*	*Nov. 13th.*	
Italian rye-grass	84.0	76.8	61.5	51.7	66.4	86.5	76.7	74.0	63.1	65.7	23.8	64.6
Broad red clover	88.4	37.3	48.6	42.5	37.2	58.7	61.3	35.9	40.8	19.4	19.3	40.1
Subterranean clover	57.0	63.7	73.3	43.0	66.8	62.9	54.0	51.9	44.5	21.0	6.7	48.8
Chicory	62.0	19.6	35.6	17.0	39.6	45.6	51.0	37.1	28.0	6.9	4.0	28.4
Mustard	91.0	65.6	66.8	82.6	71.6	76.9	62.9	64.9	63.9	21.4	10.7	58.7
Rape	97.0	84.6	77.9	87.6	72.2	86.3	83.8	84.9	77.1	53.1	29.3	73.7
Six-weeks turnip	85.0	69.3	66.3	74.6	57.8	79.8	75.1	72.3	57.1	29.6	4.5	58.6
Green top turnip	74.0	12.3	12.4	60.2	9.9	30.9	47.7	2.0	7.3	0.6	0.6	18.4
Hardy green turnip	95.0	77.1	74.8	85.8	51.4	86.9	83.4	65.7	67.8	20.4	4.0	61.7
Kohl-rabi	89.0	55.2	35.8	75.7	40.0	66.7	63.0	43.2	34.5	14.2	7.3	43.6
Thousand-headed kale	78.0	69.7	62.1	78.3	57.0	77.6	69.7	62.3	64.0	24.5	19.9	58.5
Marrow-stem kale	93.0	77.8	73.1	88.1	65.7	85.7	82.4	73.9	63.7	34.2	28.6	67.3
Scotch kale	97.0	27.7	20.5	64.1	37.1	69.0	69.4	44.9	17.8	4.9	3.8	35.9
Cottagers' kale	99.0	55.8	24.3	78.5	35.5	72.8	68.2	55.9	45.0	17.5	15.0	46.8
Rape kale	90.0	—	33.3	49.0	44.7	85.7	95.8	87.2	58.2	27.2	1.4	53.6
Brussels sprouts	93.0	46.4	41.3	63.3	55.1	75.7	74.2	43.8	27.1	11.6	12.3	45.1
Sprouting broccoli	99.0	42.1	36.3	47.0	50.0	62.2	55.0	50.5	49.4	32.5	21.7	44.7
Average for crucifers	90.8	57.2	48.1	71.8	49.7	73.5	71.5	57.7	48.7	22.5	12.3	51.2
Average for all species	86.8	55.0	49.7	64.2	50.5	71.3	69.1	55.8	47.6	23.8	12.4	50.0

Of the crucifers, rape gave the high percentage soil germination of 84.6, closely followed by marrow-stem kale and hardy green turnip with percentages of 77.8 and 77.1 respectively.

Second sowing, May 29th.

The total rainfall for the whole of this period was only slightly more than that for the first week of the period following the first sowing. The greater part of the rain fell during the week following sowing. The accumulated temperature, on the other hand, increased to a great extent. The second week had the highest figure for any one week recorded throughout the experiment.

It will be noted that the averages of the soil germinations for this sowing are well below those for the first sowing. The only species which gave any appreciable increase in soil germination for this second sowing were the two clovers and chicory. All the crucifers, with the exception of mustard and green top turnip, showed distinct decreases. It seems obvious that the very slight rainfall subsequent to sowing on this date was responsible for the lower soil germinations.

Third sowing, June 22nd.

The rainfall for this period was appreciably higher than that for the previous sowing. During the first two weeks, however, but little rain fell. The accumulated temperature showed a further rise for the whole period, but that for the first week was very much below the figures for the remaining weeks of the period.

It will be noted that this sowing gave one of the best average soil germinations. The average for the crucifers alone, moreover, far exceeded that for all the species taken together. Mustard, rape, hardy green turnip and marrow-stem kale gave soil germinations above 80 per cent. of the viable seed sown, while green top turnip gave a soil germination of 60.2 per cent., although having an average of only 18.4 per cent. for the ten sowings.

Fourth sowing, July 10th.

The climatic conditions following this sowing and the corresponding soil germinations of the species are interesting when compared with the data of the previous sowing. It will be noted that while the rainfall and the accumulated temperature for the period following this sowing were higher than for the previous sowing, the soil germinations, on the other hand, showed a decrease. It will be observed, however, that it was the crucifers which gave inferior soil germinations in this instance; Italian

rye-grass, subterranean clover and chicory gave distinctly better soil germinations for this sowing than for the previous one.

Not only did the rainfall for this period exceed that for the third period, but the temperatures were also unusually high, the accumulated temperature reaching 158°F. for the second week and the total for the period being the highest recorded. The bulk of the rain for the period fell in the third and fourth weeks following sowing, the rainfall for the first and second weeks being slight. The high temperature over these weeks would have made this slight rainfall still less effective in promoting good soil germinations, as it obviously had a pronounced drying effect upon the soil, and therefore the crucifers, which normally germinate quickly, would have been adversely affected by the climatic conditions.

Fifth sowing, July 31st.

This period gave the highest total rainfall recorded throughout the experiment, its distribution, moreover, being very favourable for promoting good soil germinations. The accumulated temperature was high for each week and fairly uniform. It will be noted that this sowing gave the highest average soil germinations, and it is interesting to observe the direct influence of rainfall on soil germinations in a comparison between the figures resulting from this sowing and those of the previous one. Although the temperature was much the same for both periods, the abundant rainfall occurring during the first two weeks subsequent to sowing on July 31st made a considerable difference in the percentage soil germinations of the viable seed sown.

Sixth sowing, August 21st.

The rainfall for this period was again adequate for good soil germinations to result. The accumulated temperature for the period dropped 103°F. from the total registered for the fifth period, but the accumulated temperature for the first two weeks after sowing were in the same category as those for the weeks following the fifth sowing.

It will be observed that the average soil germinations resulting from this sowing were only slightly less than those for the previous sowing and rank among the best of the series.

Seventh sowing, September 11th.

The climatic conditions for this period were somewhat similar to those of the first period, and show a marked contrast in the matter of temperature to the sixth sowing when comparing the accumulated temperature recorded for the first two weeks subse-

quent to sowing on these dates. The effect of this fall in temperature is clearly seen in the soil germinations for this September sowing. The average soil germinations were decidedly lower than for those of the sixth sowing and were very similar to those of the first sowing. It is interesting to observe that some species were little affected by the lower temperature, namely, Italian rye-grass, six-weeks turnip, mustard and rape, the last two giving slight increases for this sowing.

Eighth sowing, October 2nd.

This period had one of the highest rainfalls. During the week following sowing, however, there was practically no rain, the greater part falling in the third and fourth weeks of the period. The accumulated temperature had dropped 61°F. from that of the seventh period and only 28°F. was recorded for the second week. Ground frost made its first appearance at this period and reference to Table III will show that it was registered on five days in the second week following sowing.

It will again be noted that the species reacted differently to the weather conditions. While red clover, mustard, rape, hardy green turnip, thousand-headed kale and sprouting broccoli were little affected, if at all, Scotch kale, rape kale and Brussels sprouts showed quite considerable decreases in their soil germinations.

Ninth sowing, October 23rd.

While the rainfall for this period was favourable for soil germinations, the accumulated temperature was negligible after the second week, and ground frost occurred on four days of the third week and on six days of the fourth week. It will be noted that the average soil germination given by the species for this sowing was less than half that given for the previous sowing made on October 2nd.

It is interesting to note the relatively high soil germination given by Italian rye-grass for this sowing compared with its own soil germination for the eighth sowing, and with the soil germinations of the other species for the same sowing.

Tenth sowing, November 13th.

No rain fell during the first week of this period and very little during the second week, the total for the whole period being one of the lowest recorded. The accumulated temperatures had practially disappeared, and ground frost was recorded every day up to the end of the third week.

It will be noted that the only species which gave soil germination of any appreciable amount for this sowing were Italian

rye-grass, broad red clover, rape, thousand-headed and marrow-stem kales, and sprouting broccoli.

General Discussion.

It is evident from the foregoing notes on the soil germinations of the species, in conjunction with the climatic conditions prevailing at, and subsequent to, the dates of sowing, that there is a marked similarity among them in regard to their general behaviour.

The tendency is for the soil germinations to increase as the weather becomes warmer and to be at the maximum from the end of June to the end of August, and as the temperature decreases towards the autumn, so the soil germinations decrease.

It has been very evident, however, that the amount of rain which falls subsequent to any sowing plays as important a part in affecting soil germination as does temperature. This was particularly marked in the case of the first six sowings made from May 9th to August 21st, when the temperature was sufficiently high to promote good soil germinations, but the rainfall during some of the periods was insufficient, as, for example, after the sowings made on May 29th and July 10th. When high temperature was accompanied by adequate rainfall, on the other hand, the best average soil germination resulted, as from sowings made on June 22nd, July 31st and August 21st. The later sowings made from September onwards had sufficient rainfall, as is usually the case in normal years, and temperature became the prime factor.

Among the species included in the test some showed less reaction to climatic conditions than others and gave a more even series of soil germinations in consequence. The most outstanding in this respect were mustard, rape, thousand-headed kale, marrow-stem kale and sprouting broccoli. It is noticeable, however, that practically all the crucifers showed to a greater or lesser extent the same behaviour on any particular sowing.

Contrasting the soil germinations of the crucifers with those of Italian rye-grass and the clovers, it will be noted that the crucifers gave their best average soil germination when the accumulated temperature was high and the rainfall plentiful, while Italian rye-grass gave good soil germinations from the first to the ninth sowing. Red clover had a fairly even series of soil germinations and gave its best germination from the fifth and sixth sowings, while subterranean clover gave good soil germinations from all the earlier sowings with the exception of that made on June 22nd.

The above agrees with the data presented in the work on somewhat similar lines referred to at the beginning of this paper, where it was found that crucifers needed a higher temperature for soil germination than do grasses or clovers, and, moreover, require a comparatively heavy rainfall immediately after sowing in order to germinate quickly. It was also found that Italian rye-grass and red clover made their best takes in a sward from an April sowing, but that Italian rye-grass possessed the ability to establish itself from a wide range of sowing dates throughout the season.

The behaviour of chicory in the present test corresponded to that of the crucifers. The soil germinations of this species were, however, of a low order.

For purposes of comparison the relation of the average soil germinations for the ten sowings for each species to that of rape, which gave the highest figure, and which is placed at 100, are given below.

Rape	100
Marrow-stem kale	91
Italian rye-grass	88
Hardy green turnip	84
Mustard	80
Six-weeks turnip	80
Thousand-headed kale	79
Rape kale	73
Subterranean clover	66
Cottagers kale	64
Brussels sprouts	61
Sprouting broccoli	61
Kohl-rabi	59
Broad red clover	54
Scotch kale	49
Chicory	39
Green top turnip	25

From the above statement it is evident that the inherent capacity of species to germinate in the soil varies considerably, notwithstanding the fact that each species was sown at the same rate of viable seed per row in the present trial. It will be seen, moreover, if the above figures are compared with the data presented in Table IV, that the species which gave the highest average soil germinations had the widest range of " best " sowing dates.

Laboratory germination *versus* soil germination.

Attention has been called in the report on trials with grasses and clovers to the unreliability of the laboratory germination test of seed samples as an index of comparative establishment. In the statement hereunder are given groups of species having the same laboratory germinations with (1) their corresponding

average soil germinations for the ten sowings; (2) the soil germinations for the sowing made on July 31st, when the crucifers gave their highest average soil germination; and (3) the highest soil germination of each species referred to. The figures are given in round numbers.

	Laboratory germination.	*Aver. soil germination of 10 sowings.*	*Soil germination of July 31st sowing.*	*Best soil germination.*
Marrow-stem kale ...	93	67	86	88
Brussels sprouts ...	93	45	76	76
Rape ...	97	74	86	88
Scotch kale ...	97	36	69	69
Cottagers kale ...	99	47	73	79
Sprouting broccoli ...	99	45	62	62

It will be seen that the above statement in connection with comparative establishment is also true of comparative soil germination among species. For example, while the same adjustment was made in the seeding rates of marrow-stem kale and Brussels sprouts in order to sow them at the rate of 300 viable seed per row, it will be noted that the averages of the ten sowings differed in the ratio of 67 per cent. to 45 per cent. and their soil germinations for the sowing made on July 31st and their best germinations in the ratio of 86 per cent. to 76 per cent. and 88 per cent. to 76 per cent. respectively. Similar remarks apply to the other groups and also when species having contrasting laboratory germinations such as marrow-stem kale and sprouting broccoli are compared, sprouting broccoli with a laboratory germination of 99 per cent. giving inferior soil germinations to marrow-stem kale with a laboratory germination of only 93 per cent.

It should be pointed out, however, that in more extreme cases such as the laboratory germinations given by green top turnip and chicory—74 per cent. and 62 per cent. respectively—poor and erratic soil germinations may result even though the seed rate be adjusted accordingly.

Yields.

An endeavour was made to ascertain the amount of dry matter produced by the several species from each sowing. For all the sowings there were three replications of each species, namely, *a*, *b* and *c*. These replications in the earlier sowings

were used to obtain cuts at different times, for such good growth was made by the majority of the species by the autumn that it was felt desirable to compare yields from an autumn cut with those of a later spring cut from the same species and from the same sowings.

The first main cut was taken on October 6th, 1925, from the earlier sowings when, in fact, the later sowings were still in progress. At this cut all the species were cut in the *a* and *c* replications for the first three sowings, the turnips being pulled. For the fourth and fifth sowings only the following species were cut, namely, broad red clover, subterranean clover, chicory, Italian rye-grass, mustard and the tops of the three turnips.

The next cut was made on March 3rd, 1926, and was an exact replica of the October cut, the *b* replication in this instance being dealt with.

The last cut was made on April 20th, 1926, and comprised (1) the first cut taken on all the rows of each species from the sixth, seventh and eighth sowings, as well as from the crucifers, with the exception of mustard and the turnips from the fourth and fifth sowings, and (2) the second cut from the rows cut in October of the first five sowings.

It may be stated here that no yields were obtainable from the ninth and tenth sowings made on October 23rd and November 18th respectively, as, but for mere traces of Italian rye-grass, hardy green turnip and rape, the ground was quite bare, the seedlings of the other species dying back during the winter. In fact, it will be seen that many species gave no yields for the seventh and eighth sowings.

In Table V are given the yields in ounces of oven-dried material for the first cuts taken on the species for the first eight sowings. As mustard died back during the autumn its yields have not been taken into account in the average yields of the species given in the table.

I. October cut.

It will be noted that the first sowing, made on May 9th, gave the highest average weights per row, while the average yields from the sowing made on June 22nd exceeded to some extent those from the earlier sowing made on May 29th. The average yields for the remaining sowings cut in October were lower in quantity in proportion to the lateness of sowing and consequent shorter growing period. It will be observed that the averages for the crucifers alone exceeded the averages for all the species taken together in every case.

TABLE V.

Yields in ounces of oven-dried material for the first cuts taken from eight sowings made at three-weekly intervals from May 9th to October 2nd.

Species.	1st Sowing, May 9th.		2nd Sowing, May 29th.		3rd Sowing, June 22nd.		4th Sowing, July 10th.			5th Sowing, July 31st.			6th Sowing, Aug. 21st.	7th Sowing, Sept. 11th.	8th Sowing, Oct. 2nd.
	Cut Oct. 6th.	*Cut Mar. 3rd.*	*Cut Oct. 6th.*	*Cut Mar. 3rd.*	*Cut Oct. 6th.*	*Cut Mar. 3rd.*	*Cut Oct. 6th.*	*Cut Mar. 3rd.*	*Cut Apl. 20th.*	*Cut Oct. 6th.*	*Cut Mar. 3rd.*	*Cut Apl. 20th.*	*Cut in April.*		
Italian rye-grass	6.4	10.5	5.8	7.0	2.0	6.7	1.5	8.1	—	1.2	3.8	—	5.1	2.1	0.6
Broad red clover	2.3	1.6	2.6	1.1	0.5	0.7	0.2	0.9	—	0.1	0.1	—	0.3	neg.	neg.
Subterranean clover	8.8	*	3.8	4.1	1.3	2.6	0.6	2.3	—	0.6	1.9	—	1.7	0.4	neg.
Chicory	6.9	2.0	2.3	1.5	0.4	0.5	0.4	0.9	—	0.3	0.4	—	2.2	neg.	neg.
Mustard	2.6	*	4.2	*	8.0	*	4.5	*	—	3.1	*	—	*	—	—
Six weeks turnip	16.9	22.2†	18.0	16.2	18.4	13.4	7.0	6.5	—	4.0	5.8	—	9.9	4.1	0.4
Green top turnip	6.3	9.1	7.6	5.4	10.7	11.6	2.6	1.1	—	2.3	4.6	—	3.7	neg.	neg.
Hardy green turnip	15.0	21.7†	6.7	23.0	19.8	19.3	10.1	8.9	—	4.6	11.7	—	13.3	3.9	0.8
Rape	9.3	16.7†	6.4	11.5	10.2	12.9	—	—	25.7	—	—	21.5	11.7	4.1	1.4
Kohl-rabi	3.8	11.8†	2.4	12.3	5.0	2.9	—	—	3.9	—	—	8.5	3.4	neg.	neg.
Thousand-headed kale	16.3	15.9†	10.3	16.4	7.2	6.8	—	—	12.8	—	—	12.3	7.6	1.3	0.5
Marrow-stem kale	19.7	13.9†	11.4	33.8	7.1	7.5	—	—	8.9	—	—	9.8	5.6	1.7	0.2
Scotch kale	20.3	11.4†	6.7	19.4	7.4	15.3	—	—	13.7	—	—	6.3	5.6	neg.	neg.
Cottagers' kale	22.5	12.6†	5.4	16.7	6.8	10.8	—	—	13.7	—	—	7.8	5.8	0.6	neg.
Rape kale	—	—	3.0	1.1	3.8	8.6	—	—	8.7	—	—	5.1	3.4	0.5	neg.
Brussels sprouts	13.5	12.1†	4.1	9.0	6.1	5.5	—	—	12.9	—	—	8.5	5.0	0.5	neg.
Sprouting broccoli	11.8	6.5	4.8	14.7	8.6	12.5	—	—	14.5	—	—	9.3	6.4	0.5	neg.
Average of all species	12.0	12.0	6.4	12.1	7.2	8.6	3.4	4.1	—	2.0	4.0	—	5.7	1.8	0.7
Average of crucifers	14.1	14.0	7.3	15.0	9.3	10.6	6.1	5.5	12.8	3.5	7.4	9.9	6.8	1.9	0.7

* Died back during Winter. † Cut taken on July 29th.

In regard to the average yields of the third sowing being higher than for the earlier second sowing, a comparison among the species shows that Italian rye-grass, the clovers and chicory gave smaller yields for the third than for the second sowing, whereas the majority of the crucifers gave smaller yields for the second than for the third sowing. In view of the data presented on the soil germinations from these sowings, it seems probable that the lower soil germinations given by the crucifers for the second sowing compared with the third sowing gave rise to inferior plant establishment for this sowing and consequent lower yields in October. Further reference to this question is made below.

It will be noted that the yields given by mustard increased up to the sowing made on June 22nd and then decreased. No yields were obtained after the sowing made on July 31st from this species, as any growth resulting from subsequent sowings died back before a further cut was made. The yields given in October by the two clovers and chicory from sowings made later than May 29th were extremely small. It will be noted, moreover, that although quite appreciable yields were given by the tops of the turnips from the July sowings, the amount of dry matter obtained from them was inferior to that obtained from the whole plant from the earlier sowings.

II. March cut.

A comparison of the yields from this cut with those from the October cut shows the effect of allowing the species to grow on through the autumn, winter and early spring before being utilised.

In the first sowing, however, the majority of the crucifers (see Table V) were very advanced by July, so a cut was taken from them on July 29th, 1925; the yield obtained from each has been added to its March yield for the first sowing. It will be noted that in the second and third sowings the yields given in March by the majority of the species exceeded those given in the previous October. The crucifers, moreover, have again given larger average yields when taken alone than when all the species are taken together.

It will be observed that for this cut the differences in yield between the second and third sowing are generally speaking the reverse of what they were from the October cut, when the crucifers alone were considered. This would appear to be due to the fact that the existing plants in the rows of the second sowing, having more room to develop on account of the numbers

per row being restricted, had made more growth than would have been possible had the soil germination been better, and had ultimately produced as good a yield by the following spring as rows showing a better soil germination. On the other hand, evidence has been brought forward in the trials with grasses and clovers, to which reference has already been made, which indicates that both delayed germination and delayed growth of seedlings are liable to occur from normal sowings if conditions are unfavourable. It is therefore possible that one or both of these factors may have been responsible for the March yields of the second sowing exceeding those of the third sowing.

Comparatively few species were cut in March as in October from the sowings made on July 10th and 31st. It is, however, interesting to note the striking differences in the yields given by the first four species from the sowing made on May 29th and the sowing made on July 31st. Whereas Italian rye-grass gave 7.0 oz. of dry matter per row from the May sowing, it gave only 3.8 oz. from the end of July sowing. The yields of dry matter given by red clover were 1.0 oz. and 0.1 oz., by subterranean clover 4.1 oz. and 1.9 oz., and by chicory 1.5 oz. and 0.4 oz., for the May and July sowings respectively.

TABLE VI.

Yields in ounces of oven-dried material from the second cut taken on April 20th from the first to the fifth sowings.

Species.	*1st sowing. May 9th.*	*2nd sowing. May 29th.*	*3rd sowing. June 22nd.*	*4th sowing. July 10th.*	*5th sowing. July 31st.*
Italian rye-grass ...	2·9	5·5	5·9	5·1	3·9
Broad red clover ...	1·5	2·1	0·9	0·9	0·5
Subterranean clover ...			1·1	0·5	1·8
Chicory ...	5·2	2·0	0·6	0·4	0·4
Six-weeks turnip ...	*	*	*	3·8	2·7
Green top turnip ...	*	*	*	0·8	0·5
Hardy green turnip ...	*	*	*	4·7	1·3
Rape ...	4·0	4·1	2·9		
Kohl rabi ...	1·2	0·8	0·5		
Thousand-headed kale ...	2·5	1·6	1·1		
Marrow stem-kale ...	2·2	1·9	0·3		
Scotch kale ...	3·0	neg.	1·3		
Cottagers kale ...	1·7	1·5	1·1		
Rape kale ...	—	2·5	0·9		
Brussels sprouts ...	2·5	0·7	1·2		
Sprouting broccoli ...	0·5	0·6	neg.		

* Pulled in October.

III. April cut.

The yields obtained from the crucifers, with the exception of the turnips, from the two July sowings, and from all the

species from the later sowings show distinctly that good yields of crucifers can be obtained in April from sowings made from the beginning of July to the last week in August, if the species are allowed to grow uninterruptedly from the time of sowing right through the winter.

The average yield of the crucifers from the sowing made at the end of July was, however, appreciably lower than the average yield from the sowing made on July 10th. Again the yields dropped still more for the sowing made on August 21st. It is interesting to note that the tops of the turnips cut at the end of April from the August sowing exceeded in yield the tops of the turnips cut on March 3rd from both the July sowings.

The yields from the September sowing were comparatively very small, the only crucifers giving any appreciable yields being rape, six-weeks turnip and hardy green turnip.

The yields from the sowing made on October 2nd were negligible.

Second cut.

The yields from the second cut taken on April 20th, 1926, from the rows of the first five sowings previously cut in October are given in Table VI.

The figures serve to show that the species in general produced little growth during the autumn, winter and spring, after being cut back in October. It will be observed, however, that while the period of growth was the same in each case, namely, October 6th to April 20th, the yields tend to diminish in proportion to the lateness of the sowings. It seems evident, therefore, that the plants from the different sowings had not reached the same degree of establishment by the autumn in order to give equal yields during an equal period of growth even within the range of the first three sowings made from May 9th to June 22nd.

Italian rye-grass, however, has behaved differently in this respect, as has been found to be the case in previous trials, in that it gave comparatively good yields and was, therefore, obviously able to establish itself, from the first five sowings.

It will be noted that Italian rye-grass, rape, six-weeks turnip and hardy green turnip gave the largest second yields, whilst chicory gave a relatively good yield from the first sowing.

A comparison of yields among the species.

In order to draw a general comparison between the yields of dry matter per row as given by the species in this trial, the yields for the cut taken on March 3rd, 1926, have been averaged

for the first three sowings for each species and are given below with the relation of each to the highest, placed at 100. The figures for subterranean clover and for rape kale are the averages for the second and third sowings only.

Hardy green turnip	21·0 oz.	100
Marrow-stem kale	18·4	88
Six weeks turnip	17·3	83
Scotch kale	15·4	73
Rape	13·7	65
Cottagers kale	13·4	64
Thousand-headed kale	13·0	62
Sprouting broccoli	11·2	53
Kohl-rabi	9·0	43
Brussels sprouts	8·9	42
Green top turnip	8·7	41
Italian rye-grass	8·1	39
Rape kale	5·8	28
Subterranean clover	3·4	16
Chicory	1·3	6
Broad red clover	1·1	5

It will be observed from the above that the species showed a considerable range of yields, and it is very interesting to note the wide differences that existed between the yields given by the crucifers as a whole and those given by Italian rye-grass and the clovers. Hardy green turnip, six weeks turnip and marrow-stem kale each gave more than double the amount of dry matter per row given by Italian rye-grass, while the clovers, and red clover in particular, gave much inferior yields in comparison. It should be pointed out, however, that in relation to the time of sowing, the clovers were at a disadvantage as compared with the crucifers, as will be discussed later. The above comparison indicates that the different kinds of kale differ among themselves in yielding capacity.

Summary of yields in connection with dates of sowings.

It is evident that management in connection with the time of cutting the produce from different sowings made throughout the season played an important part in the yields obtained in this trial.

It has been shown that crucifers, more especially, can be sown at the commencement of the summer months to provide good yields of material by the following autumn, and that they can also be sown up to the third week in August to provide yields for the following spring, when keep is particularly valuable. When crucifers have been sown early in May it has been possible to take a cut from them at the end of July and again the following spring, when a good yield may be anticipated. When the first cut is not taken until October, however, only small and negligible yields can be expected in spring from even compar-

atively early sowings. Rape, thousand-headed kale, marrow-stem kale and Scotch kale have shown themselves capable of giving higher yields than other species under these conditions. Rape especially possessed the capacity in the present trial of giving good yields in October after being cut in July, and again in spring after being cut in October.

The evidence goes to show, therefore, that there is no definite date on which the crucifers included in this trial should be sown in order to obtain the maximum yield, but that the actual date of sowing should be regulated in accordance with the weather conditions prevailing at the time and the period when the produce will be required, whether during the autumn subsequent to sowing or in the following spring.

Sowings made from early in May to the end of June with the intention of providing keep for the autumn would tend to give most keep in direct ratio to the length of the period which they have for growth, but it has been shown that should a sowing be made under conditions unfavourable for soil germination and subsequent seedling growth, such as exist when the soil is dry and the temperature high, the yield in October from such a sowing can be exceeded by a somewhat later sowing made under more favourable conditions.

Sowing crucifers in July when, as a rule, the rainfall is high and accompanied by a high temperature, will give rise to plants that will provide abundant keep by the end of the following April. In the present experiment rape in particular gave yields far in excess of the other crucifers from the July sowings. It was found that when mustard was sown later than July, it died back before any appreciable growth had been made.

There is conclusive evidence to show that sowings of crucifers made after the end of August will result in failure as regards yields, for although the moisture may be plentiful the temperature decreases too rapidly to enable the seedlings to establish themselves before the winter sets in and ground frosts occur.

In regard to Italian rye-grass, red clover and subterranean clover, the yield data in connection with the dates of sowing brought out in this experiment are in entire agreement with the other work that has been carried out at the Welsh Plant Breeding Station with these species. It was found that Italian rye-grass was one of the few species which were able to establish themselves and give yields from September and October sowings, while red clover fell off rapidly from sowings made after early August. The case of subterranean clover is interesting in that in the present experiment this clover died back in the winter from the

first sowing made on May 9th, but remained green and gave yield in the spring from all subsequent sowings up to the sixth sowing. These data agree with the results obtained by Davies[2], who found that subterranean clover sown in June gave plants capable of overwintering, but that plants sown earlier died back during the winter. Where, however, abundant keep in autumn was required, a March or April sowing gave the best results.

A comparison between the soil germination and the yields.

In the accompanying graphs are plotted the yields of dry matter per row from the cut made on March 3rd for the first three sowings and the yields from the cut made on April 20th for the remaining sowings, together with the soil germination for each sowing for two typical crucifers.

Taking Scotch kale as an example, it will be noted that the soil germination for the first sowing was 27.7 per cent. and that it gave a yield in the following March of 11.4 ounces of dry matter. For the second sowing the soil germination had fallen to 20.5 per cent., while the yield from this sowing was 19.4 ounces. For the third sowing the soil germination rose to 64.1 per cent., but the yield fell to 15.3 ounces.

The soil germinations and the corresponding yields for the fourth, fifth and sixth sowings also show dissimilar behaviour. While the yields were negligible after the sixth sowing, the soil germinations were maintained for a much longer period.

It would appear, therefore, that there is no strongly marked connection between soil germination and yield during the spring following sowing, but that the ultimate yield to be derived from any particular sowing depends more upon the time of sowing and the subsequent climatic conditions as affecting the established plants together with all factors influencing soil fertility than upon the actual soil germination, provided the final establishment is reasonably adequate. It is obvious that a very poor soil germination would adversely affect yield, but there have been indications throughout the present trial that an inferior soil germination from end of May—early June sowing will result in a somewhat lower yield in the autumn from crucifers.

The graphs show clearly that sowings made in September and early October will give rise to quite good soil germinations, but no yields will result, as the seedlings do not mature but are killed off in the early winter.

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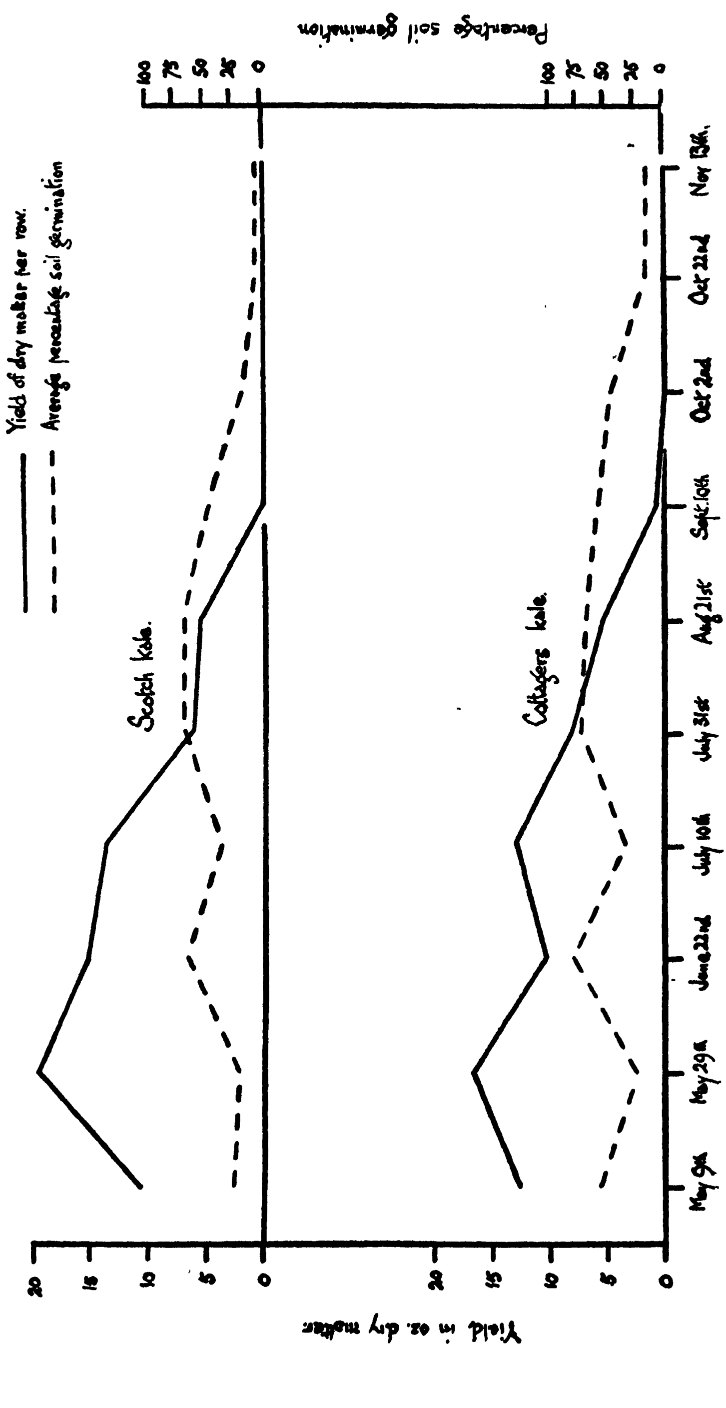
[2] Davies, William. Observations on subterranean clover. *Journ. Min. Agric.*, Vol. XXXIV, p. 455, August, 1927.

A comparison between the soil germinations and the yields for two species throughout the ten sowings.



A comparison of the percentages of dry matter of the species.

A comparison of the percentages of dry matter as existing among the different species in the test is instructive; firstly, it shows the relative amounts of produce of each which an animal would have to consume in order to obtain the same amount of dry matter, and secondly, it indicates the necessity of using only air- or oven-dried weights when comparing the yields given by different species.

TABLE VII.

The average percentage dry matter of the species with the number of pounds of the green material of each necessary to produce twenty-four pounds of dry matter.

Species.	*Average percentage of dry matter of the second and third sowings, cut March 3rd.*	*Number of pounds of green material to produce 24 pounds of dry matter.*
Italian rye-grass ...	24·0	100
Broad red clover ...	18·8	128
Subterranean clover ...	16·7	144
Kohl rabi ...	14·0	171
Sprouting broccoli ...	14·0	171
Brussels sprouts ...	13·2	182
Scotch kale ...	13·1	183
Marrow stem kale ...	13·0	185
Cottagers kale ...	12·9	186
Thousand-headed kale ...	11·8	204
Rape kale ...	11·8	204
Chicory ...	11·3	212
Rape ...	11·0	218
Green top turnip ...	9·6	250
Hardy green turnip ...	8·2	305
Six-weeks turnip ...	7·2	348

In Table VII are given the average percentages of dry matter for each species from the cut made on March 3rd, 1926, on the produce of the sowings made on May 29th and June 22nd, and also the number of pounds of the green material of each necessary to produce twenty-four pounds of dry matter.

It will be noted that Italian rye-grass had the highest percentage of dry matter; next in order came the clovers and then the crucifers, with a gradation of 14 per cent. of dry matter for kohl-rabi to 7.2 per cent. for six-weeks turnip, with chicory at an intermediate figure of 11.3 per cent. It will, moreover, be observed that among the crucifers Brussels sprouts and sprouting broccoli gave slightly higher percentages of dry matter than the kales, while the kales themselves gave figures varying only by 1.3 per cent. Comparing the crucifers with Italian rye-grass as a standard, it will be seen that in order to obtain twenty-four

pounds of dry matter it would be necessary to use from 171 to 182 pounds of the green material of kohl-rabi, Brussels sprouts and sprouting broccoli, 183-204 pounds of the kales, 218 pounds of rape, and from 250-348 pounds of the turnips as compared with 100 pounds of Italian rye-grass.

Acknowledgments.

The writer is indebted to Professor R. G. Stapledon, M.A., under whose direction this experiment was carried out. Particular thanks are due to Mr. William Davies, M.Sc., for preparing the seed data, and to Mr. J. W. Watkins, Superintendent of the Farm and Gardens, for supervising the work in connection with the sowings.

SAINFOIN OR FRENCH GRASS IN SOUTH WALES.

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1. General Distribution.

Sainfoin, or French grass, as it is known locally, grown alone or in more or less simple mixtures is a valuable leguminous crop of some importance in parts of Glamorgan and Monmouthshire. In view of the greater attention paid to short leys, this preliminary account should be of interest.

Onobrychis viciaefolia Scop. (*O. sativa*, Lam.) is found wild in Middle and South Europe, Asia Minor, Siberia and North Africa, and occasionally naturalised further northwards (1), (4). Bentham and Hooker (4) say it was " believed to be truly indigenous in southern and eastern England but not recorded from Ireland ", while Percival (8) says " The plant is probably indigenous in the midlands and south of England on dry chalky soils ". According to Alefield (Landw. Flora) the wild sainfoin has very hairy pods, the cultivated being covered with smaller hairs (1).

Davies (2) in the " General view of the Agriculture of South Wales, etc." mentions that " a plant called by the Welsh ' Gwyg bendigaid '[1] is a wild sainfoin growing naturally on the uplands adjoining the Vale of Teivy; in some of the mountain valleys of Brecon and Glamorgan and in the Valley of the Elain near Nant Wyllt, in Radnorshire ".

[1] " Blessed or Holy Vetch ".

2. Introduction of Sainfoin and other Forage Crops to Glamorgan.

According to Edward Williams (2) " sainfoin was introduced into Glamorgan under the name of French Grass about 1760 by Mr. Nicholls of Ham [nr. Llantwit Major] and soon later by Mr. Jones of Fon Mon, Mr. Harvey of St. Donats, Mr. Willis of Gileston, and Mr. Jones of Boverton, etc.". In the Vale of Glamorgan sainfoin is still known as French grass, irrespective of origin of seed or variety.

" Broad leaved or common red clover was said to be first introduced into Glamorgan by Sir Edward Stradling of St. Donats, Mr. Seyse of Boverton, and on the East Orchard Estate, about 1680-90. Soon after, this clover is said to have been introduced into Gower, on the Stout Hall Estate by — Lucas, Esq., proprietor. . . . About 1735 clover was introduced into the Uplands of Glamorgan (Blaenau). Sowing of it alone in autumn continued till 1716 when great frost destroyed it at Stout Hall, and Lucas decided to ' sow it with barley in spring. . . . It succeeded. . . . From that time to the present clover is generally sown with a spring crop, barley, oats, and sometimes beans. . . . No grass seeds were sown with clover till 1740 when ryegrass was introduced into the system ' ".

" White or Dutch clover was not brought into cultivation till about 1750 and not upon an extensive scale until red clover began to be complained of ".

" Lucerne was introduced into the Vale of Glamorgan by Mr. Winnall of Ely about 1767. Many others took it up and for some time became ' lucerne mad ' ".

Burnet was " introduced into the Vale of Glamorgan by Mr. Jones of Fon Mon on his farm at Fontygary about 1768 ".

3. At the beginning of the Nineteenth Century.

Davies (2) in 1814 wrote : " Sainfoin is still grown on a pretty large scale on the limestone soils of the Vale of Glamorgan but the crops (in general) seem inferior to those of the chalky and limestone brash soils of England ". But he quotes his correspondent[2] who asserted that " In 1804 I travelled through the chalky counties of Berks, Hants, and Wilts, and saw a great number of fields under sainfoin but none superior to what I have seen in Glamorgan and many that were inferior. Calcareous soils are particularly favourable to sainfoin : the chalky soils of Wilts, the limestone soils of Glamorgan, etc., but upon all other soils

[2] E.W., i.e., Edward Williams of Flemingstone, better known as Iolo Morganwg (1747-1826).

of whatever character they may be, the crops of sainfoin are inferior : the limestone soils, along the sea cliffs in Glamorgan (including Gower) are often not more than 4″ deep, on a rock of limestone of very open fissures, but we find very heavy crops of sainfoin upon them, and especially from Barry to Pyle. In Cardiganshire and in other counties, as well as in Glamorgan, on soils seemingly more fertile, 8 or 10″ deep, on a healthy gravelly bottom, on a dry slate rock, or an equally dry sandstone, freestone, millstone, micaceous schist, etc., I have seen crops of sainfoin that could not be compared to those on a very thin limestone rock soil where very little of anything could be expected.—E.W.".

"Several have not succeeded in the cultivation of sainfoin owing either to the soil running too soon into natural grass, or the land being too full of weeds when the seed was sown. Mr. Gale, when he entered on Boverton Farm in the Vale of Glamorgan, sowed 80 acres with sainfoin; the soil (he said) was well adapted for it; but it was in too foul a state. He was consequently disappointed. He was induced to sow so much with sainfoin owing to his 'meadows consisting of too shallow soil to be productive in common hay'. Others have succeeded better, on soils not over-driven by tillage. At Tythegston, we saw excellent sainfoin in its 9th year and lucerne in its 10th. Mr. Marment of Pyle, had scores of acres in sainfoin. Many others had 4 to 10 acres each. Sea air is supposed to be favourable to sainfoin". (2).

4. At the beginning of the Twentieth Century.

In the "Flora of Glamorgan" (5) the plant is described as "local, abundant, native (?), pascual" and is recorded from "St. Fagans, Llantwit Major, Boverton, Southerndown, abundant at Rhoose; Barry, Penarth railway embankment, Sully, Nash, Three Crosses. Often cultivated in Glamorgan. It succeeds so well on the Triassic marls and conglomerates, that it spreads and establishes itself on the railway banks, as at Sully. It seldom succeeds on the Lias, generally dying out in the second year, but near Rhoose railway station it flourishes even on this formation. I have seen the sainfoin on a field at Penarth on the boundary between the Rhaetic and Triassic marls, completely disappear from the Rhaetic end, while it continued to flourish on the Triassic portion".

The plant has been seen on railway cuttings near Sully on the conglomerate, at Porthkerry on the lias, and near Rhoose on the embankment, which contains some lias stones mixed with clinkers.

5. Farm Survey.

The crop is not returned separately in the Agricultural Census so that the acreage at present under it cannot be given. In Glamorgan there are over twenty-six farms on which it is grown at present, or has been recently cultivated. Most of them are on the lower lias whilst a few are situated on the carboniferous limestone or on the red marl and conglomerate and situated mostly around the centres where it was first introduced into the area, i.e., in the parishes of Monknash, Wick, Marcross, St. Donats, Llantwit Major, Llanmaes, Llanfair, Flemingston, St. Athans, Gileston, Llantrithyd, Llanvithyn, Llancarfan, Penmark, Porthkerry, Barry and St. Fagans. In Monmouthshire, on one farm in Llanvaches, about fifty acres have been under giant sainfoin for the past eight years, in this case on soil overlying limestone, and on two farms on the lower lias just south of Chepstow, both giant and common are grown. The Agricultural Organisers for the counties of Carmarthen, Brecon and Radnor informed the writer than sainfoin is not grown in their area, unless occasionally a few pounds are included in seed mixtures.

Sainfoin is met with, at present, most frequently on very thin soils, about four inches deep overlooking the lower lias strata generally within a few miles from the coast. There are one or two instances in which it has been tried on the drift, but it does not seem to have obtained a hold, but on the experimental plots near Ely it appears to be doing well in its second year on thin gravelly drift overlying the lower lias. The tendency has been for its cultivation to be given up first on the red marls and conglomerates. Although it is not grown so widely now as in the past, it seems that its cultivation could be extended to the carboniferous limestone, red marls and conglomerates. Some of the sainfoin leys were broken up during the war; other cases are known where the crop had been grown on the same farm for forty or fifty years, but was not tried after the coming of a new tenant who was not acquainted with it. The cost of and difficulty in obtaining reliable seed has also accounted for restriction in its use. A small amount of local seed is used, some farmers being of the opinion that the home grown is more reliable. This may be because it is cheaper and can, therefore, be sown more thickly, but most of the seed is purchased from commercial firms. The germination of one lot of home grown seed tested was about 80 per cent., but when sown at a rate taking this into consideration a good establishment was obtained. The figures for seed obtained from various firms in 1927 ranged from 45 per cent. to

96 per cent. One of the farmers' difficulties is that the germination is uncertain, and the yield is not generally as heavy as that of red clover, but crops of from two to two-and-a-half tons to the acre of hay per annum for a few years in succession are known. It is regarded by those who have experience of the crop as of greater feeding value than clover, particularly for grazing lambs and fattening cattle. The crop takes the place of clover or temporary ley, being sown with winter wheat, winter barley, spring oats and spring barley. Little (6) mentioned that "a proportion of sainfoin was occasionally sown with a reduced quantity of the other clovers" on account of clover sickness, "but it has not been so largely grown during the recent wet seasons" [following 1879]. It appears that on the whole the best results are obtained when the seeds are sown early, some of the best crops being seeded in March or early April. When sown under winter corn, the ground is well harrowed in spring before sowing and afterwards well harrowed and rolled. Both common and giant forms are used and are sown either alone or in more or less simple mixtures. When sown alone, the amount of seed varies from two-and-a-half to four bushels (or one cwt.) per acre, of unmilled seed. More frequently Italian or perennial ryegrass is sown with two to four bushels of sainfoin, the Italian being considered to help the crop, especially giant, to stand. The quantity of milled seed used is generally about 50 to 56 lb. and sometimes 2 to 3 lb. of Italian ryegrass is added under some conditions. Even this proportion of ryegrass appeared to suppress the sainfoin. Sometimes about 28 lb. of giant sainfoin is sown with perennial ryegrass. In Glamorgan it is a common practice to include a few pounds of the local red clover seed in case the sainfoin fails, but trefoil has not been seen used for filling the bottom as is recommended by some authorities. In both counties where the plant is at all thin, the open spaces are very readily filled up with indigenous rough stalked meadow grass, which becomes a feature of pastures derived from neglected sainfoin leys. On a farm near St. Donats a stock of sainfoin derived from an old common grown for forty of fifty years from seed of Lincolnshire origin, contained a large proportion of burnet, plantain and soft brome. This seed was in great request and has been grown on a number of farms in the Vale of Glamorgan. The difference in growth and flowering habits between this local seed and seed obtained from railway cuttings where sainfoin has been seeding itself down is shown in Table I.

TABLE I.

Analysis of spaced plants obtained from locally collected seed, 1925–26. Sown May, 1926. Observations, September, 1926.

	Total No. of Plants.	Growth habit.		Flowering habit.	
		Branching.	Rosette.	Flowers or Seed formed	No Flowers formed.
Lot A. Railway cuttings.	178	33	145	36	142
Lot B. Railway cuttings.	255	296	59	160	93
Lot D. Local old common.	188	29*	159	2	186

* The branches were much shorter than in Lot A.

The figures indicate that the plants found on the railway cuttings, probably derived from crops grown in the field through which the railway was laid down about forty years ago, are mixed, but the uniformity of the old common obtained from the farm shows that the latter is very pure.

6. Some Comparisons between the Common and the Giant Varieties.

Owing to the difference in persistency between the giant and common kinds, it is an important matter for the farmer to know which he is sowing, but as the seeds are not easily distinguished, trade firms generally are not prepared to guarantee the variety of a lot of sainfoin seed. A typical giant produces somewhat erect first pinnate leaves whilst the leaves of the common are more prostrate, some more so than others. The giant branches elongate rapidly at an acute angle, the central stem growing quickest, so that when the two varieties are sown at the same time they may be distinguished in a few weeks. When sown early, March to May, without a cover crop, the giant will bear flowers about a month before the common in the seeding year and will again tend to flower a second time, whereas the common varieties usually remain in the rosette stage after the first cut until the following spring. In 1927, at the first flowering period (middle to end of May) in the first harvest year, the distinction between the giant and common was less marked, and again the second flowering period (August) was very nearly identical, but after this the typical common did not show any tendency to branch or flower again as was done by the giant. The period of

flowering, however, appears to be over more rapidly in common than in giant. Another difficulty arises owing to the commercial lots of sainfoin not being always pure, as it has been observed amongst some lots of common at the trial ground that a greater or smaller proportion of the plants send up flowering stems while the others are not beyond the rosette stage. It could not be determined whether this was due to admixture at the stores or in the fields or natural crossing. The occurrence of strains which may be intermediate in character between typical common and giant is suggested.

In 1926, eleven lots of giant sainfoin (nine French and two English) were sown about the end of May. The first flowering period of these varied from August 5th to September 13th, the two lots flowering on the latter date not flowering again in that year. The majority of these flowered for the third time in the season at the beginning of September, 1927, but the two that were late in 1926 did not produce a third cut in 1927 until very late.

Some differences between common sainfoin from various sources are shown in Table II, where the time of cutting may be regarded as an indication of flowering. All were sown during the first week of June.

TABLE II.

Index and Origin.	*1st cut 1926*	*1st cut 1927*	*2nd cut 1927*	*3rd cut 1927*
C.14, C.15, French.	Sept. 13	June 13	Aug. 4	Oct. 5
C.6, Italian; C.21 undescribed, ex local firm	,, 21-22	,, 13	,, 4	,, 5
C.9, C.10, Eastern counties	,, 13	,, 13	,, 11	Not cut.
C.11, Essex ...	,, 21	,, 13	,, 11	Not cut.
C.1, 2, 3, 4 English; C.6, 8 Hants; C.12 Cotswold	,, 21	,, 10-11	,, 9-11	Not cut.
C.5 English; C.7, 22 Hants; C.13 Cotswold*	,, 21-22	,, 11	,, 26-27	Not cut.
C.17, 18, 19 Moravian†	,, 22	,, 13	,, 26	Not cut.

* Cotswold—obtained from 40-year-old stock.
† A lot of Moravian sown in 1927 is distinctly more prostrate than any English in its early growth.

7. Hardiness, Diseases and Pests.

Sainfoin appears to be more hardy than lucerne in its resistance to cold winds and frost, but it is not able to withstand poaching and treading.

The claim that French grass is remarkably free from diseases can hardly be sustained, but it is not more liable than red clover. For instance, in the first year it is subject to stem rot (*Sclerotinia trifoliorum*), which occurred in the trial grounds following foggy weather in February until midsummer. Powdery mildew (*Erysiphe polygoni*) is widespread during some seasons in summer and autumn, attacking leaves and pods. Grey mould (*Botrytis sp.*), besides attacking the stems and leaves in summer, has been noticed on the flower buds which fail to open and die. Leaf spot (*Ascochyta orobi*) is common; also Chocolate spot—a bacterial disease—is more prevalent than suspected. Rust (*Uromyces Onobrychidis*) has not been observed in this area.

In regard to pests, the plant is liable to the depredations of general feeding insect larvae; surface caterpillars were noticed on spaced plants. Leaf-eating weevils are troublesome, particularly to seedlings. These are probably what older writers referred to as the " fly ".

8. Summary.

1. An account of the introduction of sainfoin and other leguminous crops into Glamorgan is given. The past and present distribution of sainfoin in the area and farm practice is discussed.

2. Trials with a view to analysing the main differences between giant and common are reviewed, with particular reference to time of flowering and cutting. A considerable variation between different lots of both kinds is suggested.

3. Brief reference is made to fungus and insect pests.

The writer wishes to express thanks to the following for obtaining seeds from different sources :—Messrs. Harvey, Kidderminster; Sutton, Reading; Leighton, Newcastle, Staffs; Toogood, Southampton; McMullen, Hartford; Dunn, Salisbury; Garton, Warrington; McGill & Smith, Ayr; Vilmorin-Andrieux & Cie., Paris; Webb, Stourbridge. He also desires to place on record his appreciation of the kindness of the farmers of Glamorgan and Monmouthshire who have readily conducted him over their farms and supplied information required.

Lastly, acknowledgements are due to Principal Trow, Professor Stapledon and Captain R. D. Williams for suggestions and technical advice in the conduct of the investigations.

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THE INFLUENCE OF SEED RATE ON THE ESTABLISHMENT OF PERENNIAL RYE-GRASS, TIMOTHY AND ROUGH STALKED MEADOW GRASS.

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Introduction.

Previous work at the Welsh Plant Breeding Station (see Davies (1)) bearing upon the soil establishment of herbage plants has shown that under normal field conditions there is a high positive correlation between establishment and the grain weight of the seed. The data have also demonstrated that a negative correlation exists between percentage establishment and the rate of seeding. Generally speaking, however, the species of low grain weights have in all the former trials been sown more thickly than those having heavier seed. The present trial therefore has been conducted with the object of obtaining accurate establishment data for a limited number of species of grasses having seed with contrasting grain weights. The sowings in this instance have therefore aimed at so adjusting the seed rate that each of the contrasting species was included on the basis of the same number of viable seed per acre.

Material and Methods.

The trial comprising nineteen seeds mixtures was sown on April 30th, 1926, under a barley nurse at Nantsiriol—each plot (1/200th acre) was replicated four times. The soil was a good loam of uniform character. The field had been put through the rotation normally practised in the district preparatory to laying down to grass.

TABLE I.

Showing the seeds mixtures sown in lb. per acre: Nineteen mixtures.
E 75. I. Nantsiriol. Sown April 30th, 1926.

Number of Mixture.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Perennial rye-grass	4.00	8.00	12.00	16.00	20.00	40.00	—	—	—	—	—	—	—	—	—	—	—	—	—
Timothy	—	—	—	—	—	—	0.79	1.58	2.36	3.15	3.94	7.88	—	—	—	—	—	—	—
Rough stalked meadow grass	—	—	—	—	—	—	—	—	—	—	—	—	0.42	0.84	1.25	1.67	2.09	4.18	—
Montgomery red clover ..	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Alsike	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Wild white clover	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

The cereal was harvested and removed from the plots in August and each plot was critically analysed in early September, 1926, by taking ten readings on each with the usual mesh. The percentage establishment of laboratory viable seed was calculated from the data so obtained.

Table I gives details of the seeds mixtures used in the experiment. Perennial rye-grass, timothy and rough stalked meadow grass were the chief constituents of the mixtures from the standpoint of the experiment under review and the grain weights[1] of the seed lots were as follows :—

Perennial rye-grass	2·24 grams.
Timothy	0·44 ,,
Rough stalked meadow grass ...	0·22 ,,

Perennial rye-grass was sown at six rates varying from 4 to 40 lb. per acre and these were adopted as the standard. Equal numbers of viable seed of timothy and of rough stalked meadow grass were sown in comparable plots; red, alsike and white clovers were put in all the mixtures at the basal rate of 2 lb. per acre of each clover; a control plot of clovers only was also included.

Counts of indigenous unsown plants of the three grasses were made on the control and other plots and from these data it was expected that a correction factor could be calculated, thus eliminating error due to the spontaneous appearance of indigenous plants on the plots. Actually, as was rather to be expected, no plants of perennial rye-grass or timothy had made an unsown appearance at the time of analysis, but rough stalked meadow grass occurred to a considerable extent. The average occurrence (unsown) of the latter species amounted to 10.8 plants per 2½ sq. ft. and this figure was therefore used as a correction factor in connection with all the plots sown with rough stalked meadow grass.

Discussion of Results.

(1) *Percentage establishment at the six rates of seeding.*

The average establishment results for each of the three grasses in respect of six independent seed rates are shown in Table II and these data permit of the following conclusions being drawn.

(*a*) The three grasses when sown under field conditions and at equal and varying seed rates as measured by the number of viable seed show very wide differences in their powers of soil establishment. It is therefore clear that factors other than rate

[1] Grain weight = weight per 1,000 " seed ".

of sowing are responsible for the constant recurrence of a relatively poor " take " in small seeded species of herbage plants. The results strongly support the conclusion previously arrived at, namely, that each species of herbage plant has an inherent potential ability to attain to a certain relative standard of establishment in the soil and that this is at least partly controlled by the size of endosperm carried in the seed (see Davies (1)). In proportion as the food reserve (= endosperm) in the seed of species is large, so that species tends to establish itself successfully.

(*b*) Thicker sowing has lowered the establishment only at the heaviest seed rates. This phenomenon is most pronounced in perennial rye-grass, which of the three grasses under test makes the most rapid development from seed (see Davies and Thomas (2)) and therefore was the first to set up a keen sward competition. The tendency to reduce percentage establishment in the heaviest seedings of timothy and of rough stalked meadow grass is however definitely apparent. The average figures for the three species similarly indicate that only at the highest seed rates has the relative establishment materially decreased during the seeding year.

TABLE II.

Showing the percentage establishment of viable seed (seeding year) of three grasses having contrasting grain weight: each species sown at six seed rates.

E 75. I. September, 1926.

Lb. per acre of perennial rye-grass sown, the other species being sown at equivalent rates of viable seed	4	8	12	16	20	40	*Average establishment of each grass.*
Perennial rye-grass	(1)* 65.9	(2) 63.9	(3) 73.7	(4) 75.2	(5) 58.9	(6) 39.2	62.8
Timothy†	(7) 30.4	(8) 24.7	(9) 17.3	(10) 21.8	(11) 25.8	(12) 18.0	23.0
Rough stalked meadow grass†	(13) 16.9	(14) 15.0	(15) 22.3	(16) 18.8	(17) 24.6	(18) 17.2	19.1
Average establishment of the three grasses.....................	37.7	34.5	37.8	38.6	36.4	24.8	—

* The figures in brackets indicate the number of the mixture, see Table I.

† Timothy and rough stalked meadow grass sown at the same rate in terms of viable seed per acre as the rye-grass in each case.

(2) *Influence of rye-grass upon the establishment of red, alsike and white clovers.*

Table III summarises the percentage establishment data obtained in the experiment for the three clovers when the latter were sown with perennial rye-grass. There is fairly clear evidence to show that in proportion as the seeding of rye-grass has been increased so the percentage establishment of each clover species

TABLE III.

The effect of increasing the seed rate of rye-grass upon the percentage establishment of viable seed in the case of the three clovers (seeding year).

E 75. I. September, 1926.

Number of mixture	1	2	3	4	5	6	*Average establishment of each clover.*
Seeding per acre of perennial rye-grass sown	4lb.	8lb.	12lb.	16lb.	20lb.	40lb.	
Montgomery red clover	52.8	32.6	31.4	41.3	19.8	19.2	32.8
Alsike clover	26.9	24.9	20.9	17.9	10.3	13.9	19.1
Wild white clover	14.4	14.4	13.0	18.2	12.5	10.4	13.8
Average establishment of the three clovers together	31.4	24.0	21.8	25.8	14.2	14.4	—

becomes less. These data, therefore, show that so far as the establishment of clover in the seeding year is concerned perennial rye-grass may in some cases have an important and a deleterious influence upon them. Considering the average results of the three clovers in the present trial this is quite conclusively shown to be the case.

Grateful acknowledgments are due to Mr. W. E. J. Milton, N.D.A., for laying out the experiment in the writer's absence, to Mr. Ll. I. Jones, B.Sc., for assistance in the analytical work, and to Mr. J. M. Edwards, Nantsiriol, Clarach, for kindly giving facilities to conduct the trial on his farm.

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METEOROLOGICAL CONDITIONS AT ABERYSTWYTH 1894—1927.

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I. Introduction.

Of all the factors contributing to the farming industry weather plays the chief part. Not only are the farm animals at any particular time dependent upon its vagaries but the crops make a greater response to differences in the weather than to any

cultural or manurial treatment. This factor has, therefore, to be taken into consideration whenever the behaviour of a crop is studied.

In forming an opinion of the climate of any district the chief features to be borne in mind are rainfall, sunshine, temperature and wind. All these are, however, closely inter-related; the amount of sunshine during a particular period depends upon the amount and frequency of rainfall; the temperature depends upon the wind and sunshine; whilst the rainfall is largely governed by the wind and temperature.

Apart from the alternation of day and night, the chief factor that governs the weather is the variation in length of day, which having a regular periodicity sets an oscillating limit to the maximum hours of sunshine and also causes a corresponding periodicity in temperature. Apart from this seasonal periodicity within each year, no other meteorological rhythms are as yet understood to such an extent as to permit of prognosticating with reasonable assurance any periodicity in the weather calendar.

Meteorological records have been kept at Aberystwyth by Dr. Abraham Thomas since 1893, and the data presented here are for the most part drawn from that source.[1]

For comparing the effect of the weather on crops it was found advisable to divide the year into seasons: winter, comprising December, January and February; spring, March, April and May; summer, June, July and August; and autumn, September, October and November. The complete year in every case, therefore, includes the data for December of the previous year.

According to the usual practice, a "Rain Day" has been so designated whenever there was 0.01 inch or more of precipitation.

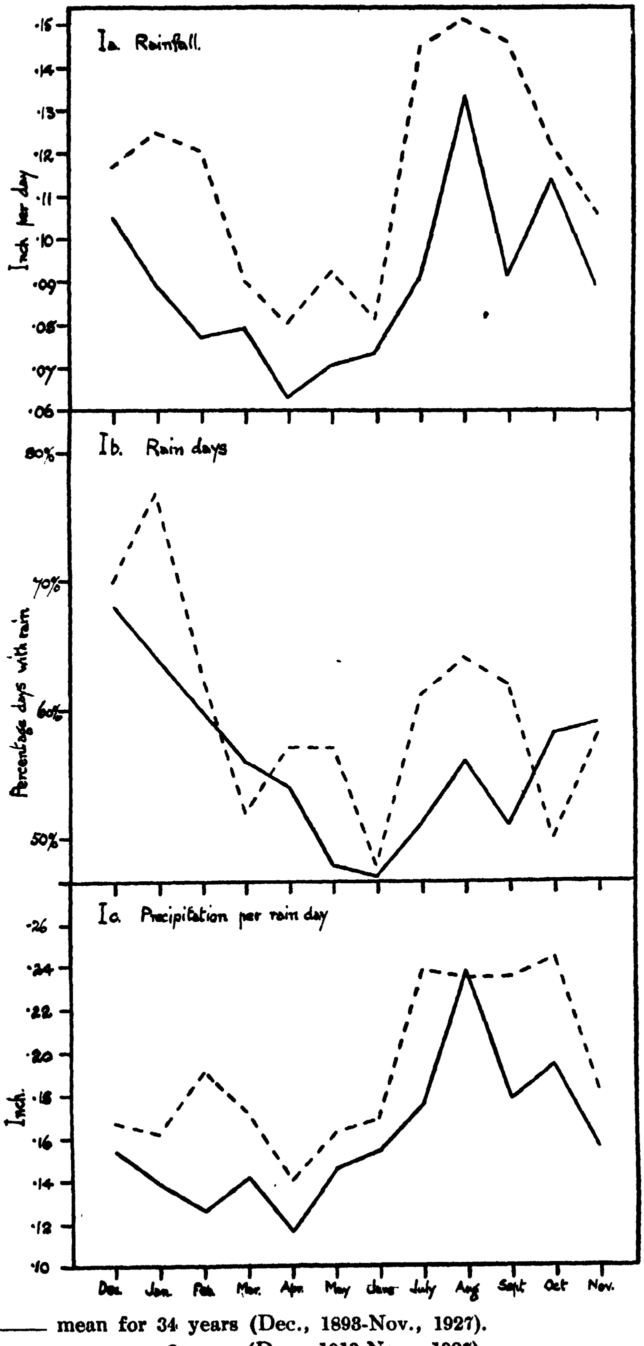
II. Monthly Means.

1. *Rainfall.*

The figures set out in Chart I (*a*), (*b*) and (*c*) show the mean values per month as averaged for the 34-year period at Aberystwyth. From these figures it will be seen that the period from February to June was much drier than the rest of the year, and that though April is the traditional month of showers, it actually had the least precipitation and also the least amount per rain day. August, the popular holiday month and the

[1] During the last three years such records have also been kept at the Plant Breeding Station. These agree so closely with those taken by Dr. Thomas that they have been utilised for the latter period in this survey.

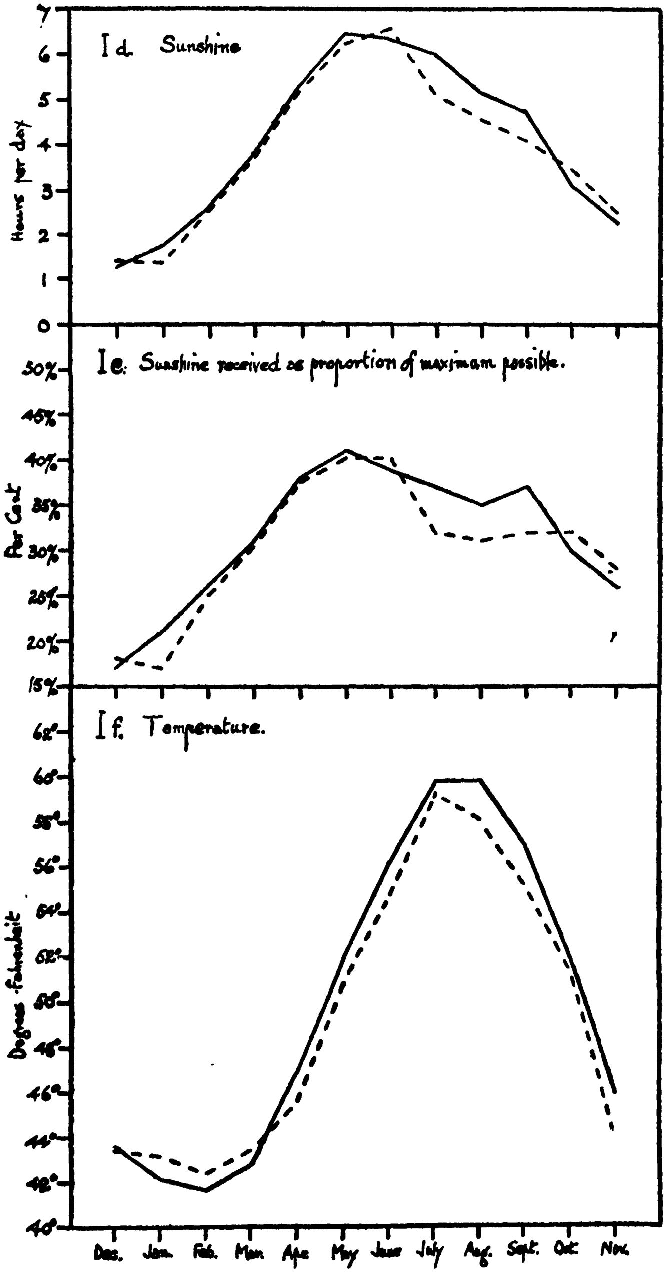
CHART I.



——————— mean for 34 years (Dec., 1893-Nov., 1927).

\- - - - - - ,, ,, 8 ,, (Dec., 1919-Nov., 1927).

CHART I.—*Continued.*



———— mean for 34 years (Dec., 1893-Nov., 1927).
- - - - - „ „ 8 „ (Dec., 1919-Nov., 1927).

farmers' harvest time, had nevertheless by far the greatest precipitation, and stood in striking contrast to the winter months of January and February. In fact, of all the long day months from April to September, August had the most frequent recurrence of rain days and along with that it had the still more marked distinction of having the greatest fall per rain day throughout the whole year.

The frequency of the rain day also deserves comment; even in May and June rain fell during practically half the days, whilst during the rest of the year, rain days occurred much more frequently than every alternate day.

2. *Sunshine.*

The mean figure for the proportion of maximum possible sunshine over the whole 34-year period shows what a small proportion of sunshine was actually received to what there might have been if the sky were always clear—only 38 per cent.[2]

Sunshine naturally varies with the length of day, but what is interesting is the relation of the sunshine actually received to the maximum possible at various times of the year (see Chart I (*e*)); during thè long day months, when the sunshine received bears the greatest proportion to the amount possible, it is only 40 per cent., whilst during the short day period the corresponding proportion falls as low as 17 per cent.

The inter-relation of sunshine and rainfall is generally believed to be a simple one of " more rain less sunshine ", but the data plotted on Chart I (*b*) and (*e*) show that the proportion of sunshine received at any particular month of the year to the maximum possible sunshine for that period, had the sky been clear, bears a much closer relation to the number of rain days than to the actual rainfall.

In Chart II, where the proportion of sunshine received per month to the maximum possible has been plotted against the percentage days with rain, it is shown that the correlation between them is so close that during the winter months these values agree almost perfectly, whilst in the case of the summer months the plotted points fall to a fairly equal extent on each side of the line, which is a prolongation of that passing through the points for the winter months. The formula for this line is—

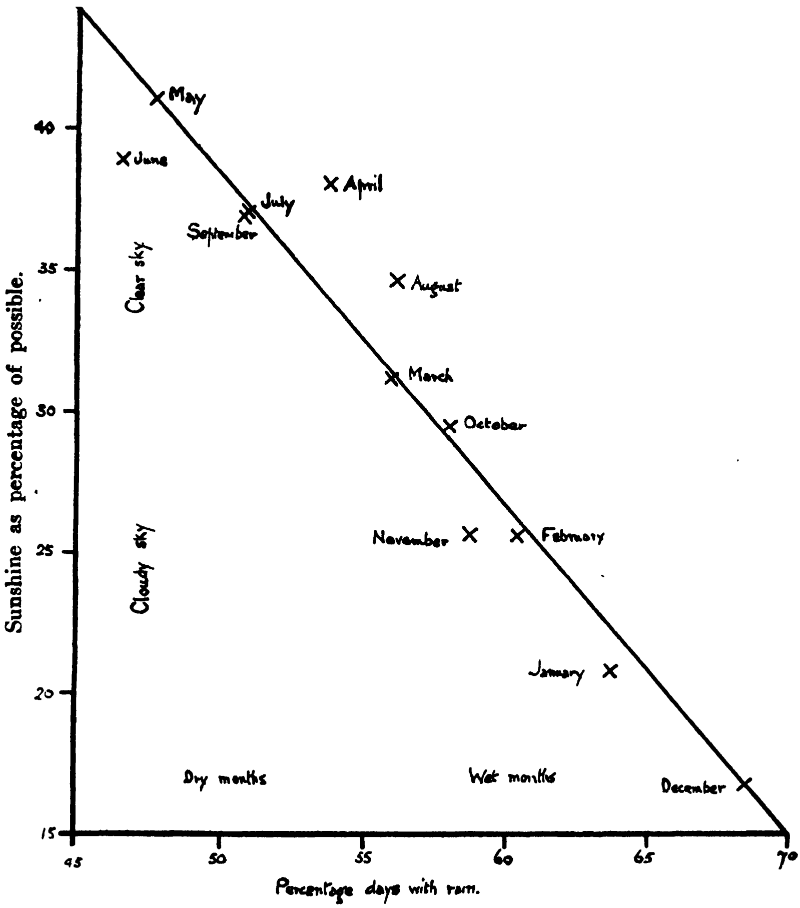
$$y = 97 - 1.17\,x$$

where x is the percentage of rain days
and y is the percentage possible sunshine.

[2] Yet Aberystwyth compares exceedingly well as regards sunshine with any seaside resort in the British Isles.

June and November are the only months where the amount of sunshine falls short of what would be proportional to the percentage of days with rain, whilst April and August are the only months where the sunshine is greater than proportional to the percentage of rain days.

CHART II.



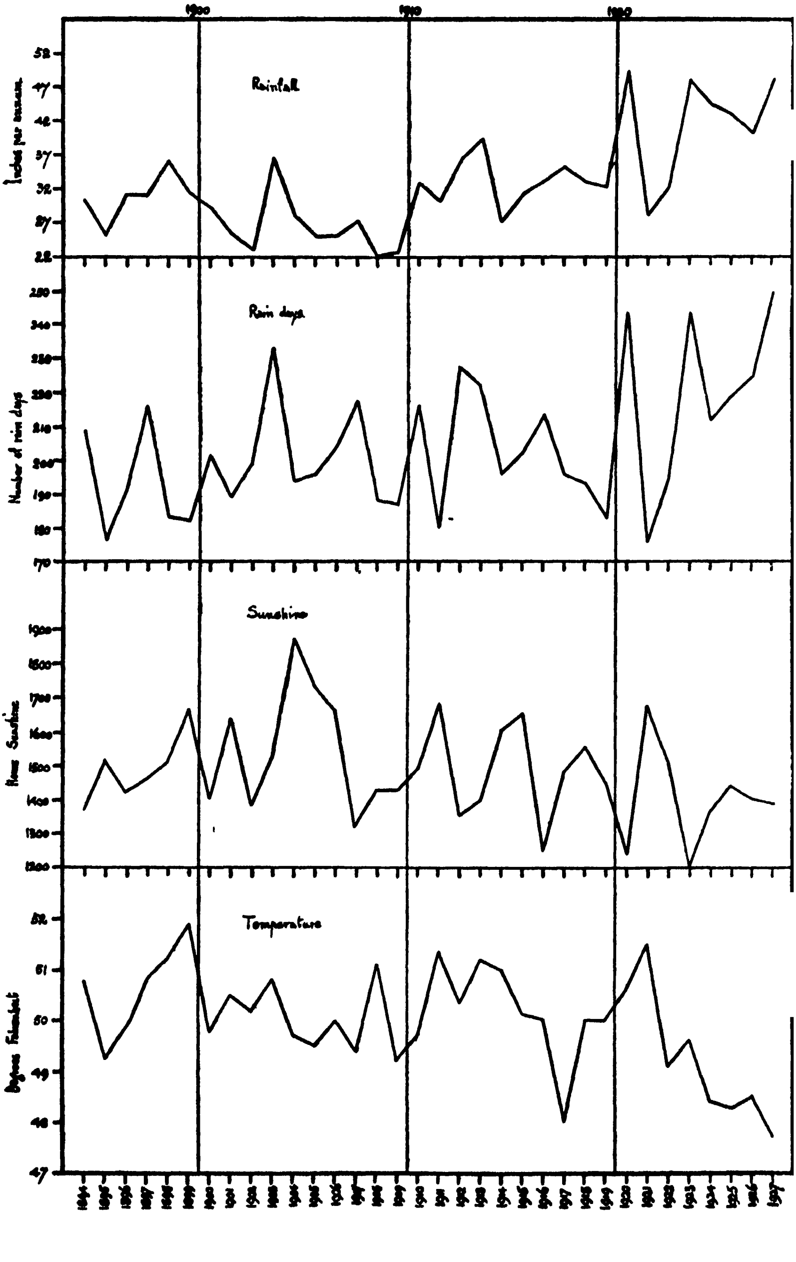
The state of affairs in November, when thick fog is traditional, may possibly be connected with the rapid fall in temperature, and this following the heavy rainfall of October (see Chart I (*f*)); whilst the clear sky of April, even when showers of rain are frequent, may be connected with the correspondingly rapid rise in temperature over the same part of the thermometer scale, and this following in the wake of the dry month of March.

During June, thunderstorms frequently disturb the sky, causing it to become sultry, but no rain falling.

3. *Temperature.*

Chart I (*f*) shows how the temperature varied from month to month on the 34-year average. It followed fairly closely the changes in the length of day, but the rise or the fall was later

CHART III.



by a month or six weeks, the highest temperature being reached in July and the lowest in February. In the case of individual years, however, the highest temperature was frequently not reached till August, whilst the lowest temperature was often reached in January or occasionally not till March.

III. Distribution of Rainfall, Sunshine and Temperature values per season.

Chart III shows for each year from 1894 to 1927 the amount of rainfall, number of rain days, hours of sunshine, and the mean temperature.

From this Chart it will be seen that the rainfall varied from 22 to 49 inches per annum; the number of rain days from 177 to 249; the hours of sunshine from 1,202 to 1,869, and the mean temperature from 47.7°F to 51.9°F.

The Chart also shows that there was a very high positive correlation between the rainfall and the number of rain days per annum, whereas there is a distinct negative correlation between each of them—rainfall or rain days—and the hours of sunshine.

1. Rainfall.

(*a*) *Total Rainfall.*

The rainfall per annum over the years 1894 to 1927 varied in such a way that when the years are grouped in an empirical manner there is an exceedingly wide difference in the average rainfall per annum within those groups.

Such grouping is shown by the figures in Table I, where the first period comprises 1894-99, the second 1900-09, the third 1910-19, and the fourth 1920-27.

Indeed, so distinct is the variation between these consecutive periods that even when the individual records for all the years are rearranged in such a way as to group together all the " dry years " (years with less than 30 inches of rainfall), all the " wet years " (years with more than 40 inches of rainfall), and the rest as years of " medium rainfall ", the average rainfall per annum for each of these three groups, " dry ", " medium " and " wet " years, corresponds closely with the average rainfall per annum for the three periods 1900-09, 1910-19, and 1920-27 respectively.

(*b*) *Rainfall per Season.*

When the average rainfalls within these " periods of years " are further divided into their seasonal constituents, it is seen that this variation in amount occurs fairly evenly in all the four seasons of the year—winter, spring, summer and autumn—as

TABLE I.

Showing the comparison of consecutive periods of years.

	Period.	Total per annum.	Winter.	Spring.	Summer.	Autumn.
			(a) Rainfall.			
I	1894–99	30·74	7·89	6·13	8·10	8·49
II	1900–09	26·43	6·35	5·27	7·25	7·56
III	1910–19	32·96	8·54	6·92	8·47	9·05
IV	1920–27	41·86	10·92	8·02	11·60	11·33
	Average	32·7	8·3	6·5	8·8	9·1
			(b) Rain Days.			
I	1894–99	193	55	45	45	47
II	1900–09	201	55	49	47	50
III	1910–19	203	59	47	44	53
IV	1920–27	220	63	51	54	52
	Average	204	58	48	47	51
			(c) Sunshine.			
I	1894–99	4·05	1·73	5·39	5·93	3·17
II	1900–09	4·15	1·98	5·10	5·92	3·60
III	1910–19	4·09	1·84	5·00	6·10	3·43
IV	1920–27	3·83	1·77	4·84	5·31	3·41
	Average	4·04	1·84	5·05	5·82	3·43
Proportion of maximum possible sunshine		33%	21%	37%	37%	31%
			(d) Temperature.			
I	1894–99	50·5	42·5	47·7	59·2	52·5
II	1900–09	50·2	41·9	47·2	59·0	52·9
III	1910–19	50·2	42·5	47·8	59·0	51·6
IV	1920–27	49·3	43·0	46·5	57·2	50·4
	Average	50·0	42·4	47·2	58·6	51·9
			(e) Rainfall Distribution.			
			per cent.	per cent.	per cent.	per cent.
I	1894–99		25·7	20·0	26·4	27·6
II	1900–09		24·0	20·0	27·4	28·6
III	1910–19		25·9	21·0	25·6	27·5
IV	1920–27		26·0	19·2	27·6	27·0
	Average		25·3	20·0	26·8	27·8

TABLE II.

Showing the comparison of selected years—dry, medium and wet years.

Years.	*Total per annum.*	*Winter.*	*Spring.*	*Summer.*	*Autumn.*
		(a) Rainfall.			
Dry ...	25·69	6·40	5·29	7·24	6·83
Medium ...	33·18	8·64	6·77	8·47	9·28
Wet ...	45·56	11·40	8·48	12·67	13·00
		(b) Rain Days.			
Dry ...	193	54	47	45	47
Medium ...	202	58	47	45	51
Wet ...	232	66	52	56	57
		(c) Sunshine.			
	Average per annum.				
Dry ...	4·57	1·91	5·20	6·00	3·65
Medium ...	4·07	1·79	5·14	6·00	3·31
Wet ...	3·67	1·79	4·48	5·10	3·28
		(d) Temperature.			
Dry ...	50·8	41·7	47·2	59·0	52·5
Medium ...	50·3	43·0	47·5	59·0	51·8
Wet ...	48·9	42·8	46·5	57·0	49·7
		(e) Rainfall Distribution.			
		Per cent.	Per cent.	Per cent.	Per cent.
Dry ...		24·7	20·5	28·2	26·6
Medium ...		26·1	20·4	25·5	28·0
Wet ...		25·0	18·6	27·8	28·6
		(f) Rainfall per Rain Day (inch).			
Dry ...	0·133	0·118	0·112	0·161	0·145
Medium ...	0·164	0·149	0·144	0·188	0·182
Wet ...	0·197	0·173	0·163	0·226	0·228
Average ...	0·160	0·144	0·136	0·187	0·173

shown by the percentage distribution of rainfall in Table I (*e*), where the rainfall for each of the four seasons never varies by more than 2 per cent. between any of the four consecutive periods.

This uniformity of the distribution per season over the four consecutive periods gives great significance to the distribution between the four seasons of the year : the spring has the least rainfall; the autumn has most rainfall; whilst the summer has a slightly higher rainfall than the winter. A similar distribution is also found amonst the " dry ", " medium " and " wet " years.

2. Rain Days.

The number of rain days, though it varies between the " dry years " and " wet years ", does not vary to nearly the same degree as the rainfall itself (see Table II); the actual precipitation in the " wet years " was on the average nearly 80 per cent. greater than in the " dry years ", whereas the corresponding increase in the number of rain days was only 20 per cent. Thus it is seen that during the " wet years " not only were there more rain days but that on each of those rain days there was on the average a greater fall. The figures in Table II (*f*) show that the average rainfall per rain day increased from 0.133 inch in the case of the " dry years " to 0.164 inch in the case of the " medium years ", and still further to 0.197 inch in the case of the " wet years ".

When the four consecutive periods—1894-99, 1900-09, 1910-19, and 1920-27—are considered, the average number of " rain days " per annum shows a similar variation (see Table I (*b*)) to the " dry " and the " wet " years; the average number of " rain days " varied only from 193 to 220 days, whereas the " rainfall " varied from 26.43 to 41.86 inches per annum, and it was only in the last period (1920-27—very wet years) that the average number of rain days increased materially.

The relation between the amount of rainfall and its distribution (number of rain days) per season is very striking : during a rain day in summer or autumn much more rain falls than during a rain day in winter or spring. In other words, the spring has far less rainfall than the summer, yet it has quite as many rain days (48 in spring and 47 in summer), and though the winter has slightly less rainfall than the summer, still it has many more rain days (58 against 47). The autumn slightly exceeds the summer both in regard to amount of rainfall and the number of rain days.

3. Temperature.

The mean temperature for each year as a whole did not show any correlation with the rainfall or number of rain days and only a low correlation (positive) with the amount of sunshine (see Chart III).

The temperature as averaged per season within the four consecutive periods (see Table I (*d*)) showed only slight variation. During the very wet period (1920-27), however, the range between winter and summer was narrower, the temperature being lower for the spring, summer and autumn, and higher for the winter. Where the temperatures per season have been grouped according to the nature of the years—dry, medium, or wet (see Table II (*d*)) a similar phenomenon occurs : wet years have mild winters and mild summers, whilst dry years have cold winters and hot summers.

TABLE III.

Showing rainfall per month (inches) December 1919—November 1927.

	Average per month, 1920–27.	*1920*	*1921*	*1922*	*1923*	*1924*	*1925*	*1926*	*1927*
December (previous year)	3·63	5·49	2·62	3·38	4·18	3·14	5·44	3·23	1·60
January	3·89	3·53	4·72	3·89	3·68	3·53	3·54	3·92	4·36
February	3·39	2·25	0·33	4·00	5·89	0·91	7·04	3·40	3·31
March	2·78	6·51	3·42	2·96	1·25	1·91	1·39	1·16	3·64
April	2·39	5·38	1·50	1·89	2·44	1·88	2·30	1·69	2·07
May	2·84	4·25	1·89	1·56	3·64	3·32	4·13	1·98	1·97
June	2·44	3·32	0·60	1·06	1·17	5·35	0·08	2·19	5·80
July	4·48	5·82	1·69	3·51	4·51	5·78	3·37	5·08	5·96
August	4·68	2·42	5·67	4·23	3·53	5·88	4·71	4·69	6·35
September	4·37	5·36	1·83	3·61	4·70	6·08	4·41	5·00	6·00
October	3·78	3·04	2·58	0·65	7·85	4·89	4·10	3·36	3·78
November	3·18	1·78	2·40	1·58	4·97	1·92	2·34	6·74	3·68
Total per annum		49·15	29·25	32·32	47·81	44·59	42·85	40·44	48·52

IV. Weather for the last eight years. December 1919—November 1927.

The foregoing data have shown this period to be extraordinarily wet; it will, however, be interesting to see how the weather varied within the period itself. Tables III—VI have been arranged to give the monthly values.

TABLE IV.

Showing number of rain days per month. December 1919—November 1927.

	Average per month, 1920–27.	*1920*	*1921*	*1922*	*1923*	*1924*	*1925*	*1926*	*1927*
December (previous year)	22	26	16	23	25	23	22	21	17
January	24	26	28	23	23	22	18	22	29
February	18	19	5	18	24	9	27	21	20
March	16	23	24	18	14	8	15	9	18
April	17	28	10	13	19	13	17	16	20
May	18	18	16	11	21	24	24	17	11
June	14	17	11	17	11	19	1	17	22
July	19	27	10	18	17	18	16	20	26
August	20	15	19	17	23	22	17	20	25
September	19	15	9	16	22	21	22	19	25
October	16	13	10	6	26	18	17	17	18
November	17	16	18	15	18	13	14	26	18
Total per annum		243	176	195	243	210	210	225	249

The figures for the years 1920, 1928, 1924 and 1927 (see Table III) show strikingly the heavy rainfall of those years, whilst the 1921 figure indicates drought.

The extra heavy rainfall during the summer of 1927 is also patent from the figures; for the four summer months—June to September—it was over 24 inches, being the highest since the records have been kept at Aberystwyth (1894).

From Table III it may also be seen how erratic was the rainfall for June; during this month the crops frequently suffered from severe drought. On some occasions, however, June was wet, but in all those cases a still heavier rainfall occurred in July.

TABLE V.

Showing mean daily sunshine (hours) per month. December 1919—November 1927.

	Average per month, 1920–27.	*1920*	*1921*	*1922*	*1923*	*1924*	*1925*	*1926*	*1927*
December (previous year)	1·41	1·45	1·00	1·20	0·74	1·40	1·25	2·83	1·95
January	1·38	1·55	0·64	1·76	1·32	1·69	1·23	1·61	1·25
February	2·49	2·60	3·15	2·63	2·17	2·76	2·03	1·64	3·00
March	3·70	3·48	3·19	4·87	3·37	5·77	3·22	2·72	3·00
April	5·29	2·50	6·90	7·08	4·92	5·21	6·27	4·54	4·89
May	6·22	5·18	8·66	6·70	6·32	4·73	4·78	6·30	7·09
June	6·56	5·68	8·09	5·75	4·85	4·06	10·87	7·41	5·74
July	5·11	3·90	7·48	5·48	4·37	4·85	6·00	5·32	3·93
August	4·56	3·90	4·70	4·50	4·50	3·63	4·75	5·45	5·03
September	4·10	4·30	6·44	3·88	4·44	2·91	3·87	3·43	3·56
October	3·46	4·28	4·00	4·40	2·63	3·10	2·39	3·23	3·68
November	2·18	1·89	2·37	1·43	3·07	2·64	3·92	2·05	2·45
Mean per annum		3·39	4·72	4·14	3·56	3·56	4·21	3·84	3·80

With the exception of August, 1920, and July, 1921, the months of July and August have invariably been wet, and furthermore July almost invariably had more rain days than June and particularly so in wet years. This has been very unfortunate from the farmers' point of view, as July is the month during which most of the hay is cut and August the month during which the corn crops are usually harvested.

Modern researches on the nutritive value of hay cut at different times show conclusively that the feeding value of the hay usually deteriorates very markedly the later it is left uncut after the middle of June. It has also been shown that the bulk gained by postponing the cutting of hay from June to August is lost in the aftermath. In view of these facts the farmer would, therefore, be well advised to start the hay harvest early in June, when he is also likely to obtain the most favourable weather conditions for harvesting.

TABLE VI.

Showing mean temperature (degrees Fahrenheit) per month. December 1919—November 1927.

	Average per month, 1920–27.	*1920*	*1921*	*1922*	*1923*	*1924*	*1925*	*1926*	*1927*
December (previous year)	43·5	46·9	42·0	45·9	45·7	42·9	45·8	38·8	40·8
January	43·2	42·8	46·4	42·6	43·9	44·1	43·4	41·5	41·2
February	42·4	44·6	42·3	42·7	44·8	39·9	41·1	44·0	40·2
March	43·4	44·8	45·4	42·1	45·5	42·5	40·4	42·6	44·3
April	45·6	46·8	47·2	42·5	47·4	44·6	44·4	47·7	44·4
May	50·9	52·3	51·3	52·9	49·1	50·6	50·3	49·0	51·7
June	54·8	57·3	57·5	55·9	53·9	54·0	53·4	53·3	52·7
July	59·3	57·6	63·7	56·2	61·6	56·5	59·5	60·7	58·8
August	58·1	56·9	60·1	57·2	59·4	55·5	58·3	59·6	58·0
September	55·3	56·2	58·4	55·0	54·8	54·8	52·2	57·3	54·1
October	51·6	53·9	57·8	49·5	51·4	50·5	51·0	46·6	51·7
November	44·2	48·1	45·6	46·2	41·6	45·1	39·8	43·5	44·0
Mean per annum		50·7	51·5	49·1	49·9	48·4	48·3	48·7	48·4

When comparing the variation in temperature from month to month on the 34-years average (see p. 257) it was found that the rise or the fall fluctuated with the length of day. When the variation for the same month in different years is considered, it is found that the temperature does not vary with sunshine or rainfall to any close degree. From general experience of the time at which the growth seasons commenced, however, the temperature factor is of supreme importance. The data collected for the last eight years strongly suggest that the time at which the temperature crossed the 45°F was roughly the beginning of the active growing season for most of our commonly grown farm crops and pastures, but before this can be verified it is necessary to have accurate phenological data.

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FIELD TRIALS WITH WELSH SEED POTATOES.

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One of the most important of the practical results of the researches on virus diseases which have been carried out in many countries during recent years is to throw light on the conditions under which successful seed potato production is possible. There is ample evidence that virus diseases are in the main responsible for the falling off in yield of home-saved seed, and the Scottish seed potato industry owes its predominant position largely to the fact that in many parts of Scotland the stocks are relatively free from these diseases and from the insects which spread infection.

If this is true it at once suggests that similar conditions, suitable for the production of seed potatoes, might be found in some localities in Wales; a conjecture which has been fully confirmed in the course of a survey of potato stocks carried on for several years in North Wales by the senior writer. Amongst the cases examined may be cited the following :—

Anglesey. Llandegfan, local variety, " Penmon Kidney ", grown for seventy years without change of seed and, when examined, showed only 5% mosaic, " May Queen " (twelve years, 1% mosaic); Beaumaris, local variety said to be " Early Kemp " (sixty years, no disease); Holyhead, " Shamrock " (twenty-five years, no disease), " Sharpe's Express " (twenty years, no disease), " May Queen " (eighteen years, 3.9% mosaic), " British Queen " (twenty years, no disease), " Great Scot " (four years, no disease), " Sharpe's Victor " (four years no disease); Bodorgan, " New Century " (twenty-one years, no disease); Llangwyllog, " Up-to-Date " (seven years, no disease); Aberffraw, " Flourball " (twenty-five years, no disease).

Caernarvonshire. Edeyrn, " British Queen " (twenty years, no disease); Sarn, " Skerry Blue " (sixty years, no disease), unnamed variety similar to " Abundance " (obtained from Russia twenty-five years ago, no disease).

Flintshire. Caerwys, " Sir John Llewelyn " (seven years, 1% mosaic).

Denbighshire. Denbigh, an unnamed early variety (fifteen years, no disease).

Even after making full allowance for the possibility that, in some cases, the grower had over-estimated the length of time during which the stocks had been grown without change of seed, it seemed clear that degeneration must have been an extremely slow process on these farms. Except in the case of the Bodorgan centre (where, although the crop was grown in a sheltered garden infested with aphides, a special effort was always made to lift the early varieties as soon as possible) all the stocks had been grown on exposed land and insect carriers were shown by the writers' colleague, Dr. C. L. Walton, to be scarce or absent. In many of these cases, too, degeneration on neighbouring farms seemed to be rapid and the growers reported their inability to keep stocks for more than one or two years; such crops invariably proved to be grown under sheltered conditions and aphides were numerous.

However interesting and suggestive these observations were, they could not replace the more exact results to be obtained from field trials with known stocks. Consequently trials were laid down in a number of centres in the Principality with a view to testing the rate at which one of these diseases (leaf-roll) spread from a known source of infection to healthy plants. Some of the results which have been published in this Journal (1) proved that the rate of spread varied considerably in different centres, and that it was related to the number of insect carriers present.

Following on these transmission trials an effort is being made to test the practicability of producing seed potatoes on a commercial scale in North Wales, the work involving close supervision of the stocks each year and finally a critical test of their cropping power as compared with a good sample of Scotch seed. Since, however, the final cropping trials cannot be carried out until the stocks have been grown continuously for several years, it is unnecessary to give fuller details of this scheme at present. In the interim it seemed advisable to carry out a critical test of the cropping power of such other stocks as were known to have been in cultivation in North Wales for a number of years without change of seed. In order to keep the trials within reasonable limits of size, only two varieties ("Kerr's Pink" and "Great Scot") from several centres were tested, after sufficiently careful inquiries had been made to justify confidence that the stocks had, in fact, been grown for the period stated. As a matter of interest, a third variety ("Arran Chief") was secured from one centre and tested against Scotch seed. Although in this variety some falling off in yield had been noticed, in all the other cases the grower believed that the crop showed little or no falling off

as compared with the yield when first obtained from Scotland. It should be understood that none of these stocks had received the close supervision required by the larger scheme now in operation, and some had not even been seen by the present writers.

Sources of Stocks used.

The three varieties, " Kerr's Pink ", " Great Scot " and " Arran Chief ", were obtained from the following centres :—

Pwllheli. " Kerr's Pink " (ten years grown) and " Great Scot " (fourteen years).

Brynengan. " Great Scot " (five years).

Trawsfynydd. " Kerr's Pink ", " Great Scot " and " Arran Chief ", all grown for at least five years. These stocks had been kept under observation by the Agricultural Organiser for Merioneth for the last three years, who reported that the yield was maintained in the first two but that there was a falling off in the case of the " Arran Chief ".

Madryn Castle Farm Institute. Stocks of " Kerr's Pink " and " Great Scot " were grown for two years, under the direction of Mr. Edwin Jones, at two centres, Llanberis and Cesarea. For this trial, however, it proved impossible to secure stocks from these upland farms, so a quantity of seed was obtained, which, after having two years at Llanberis or Cesarea, had been grown a third year at the Institute. With these was obtained some Madryn once-grown Scotch seed as a measure of the amount of disease the Llanberis and Cesarea stocks might have contracted as a result of their one year sojourn at the Institute.

Plan of Trials.

Although the land selected for the trial was as uniform as could be found, it sloped upwards and the soil varied from a rather stiff loam at the lower end to a light loam at the top. Each variety constituted a separate trial and, except for " Arran Chief ", was laid down as replicated series in " randomised " rows of sixty tubers each. The tubers were of seed size and were planted at intervals of 15″ in rows 27″ wide. The chequerboard arrangement of the trials reduced to a minimum any error due to variations in soil fertility; the rows running in the same direction as the slope. All the seed was received shortly before planting time, so that it remained unboxed. There was, however, insufficient seed from Madryn, Llanberis and Cesarea to give the desired number of replications, so that their places were taken in some of the series by new Scotch seed of the same variety, which had been obtained for other purposes the previous autumn and had been boxed during the winter. This enabled a

comparison to be made of the yields obtained from boxed and unboxed seed from Scotland.

In the " Kerr's Pink " trial the Scotch seed was replicated ten times, the Pwllheli, Brynengan and Trawsfynydd stocks seven times, the Llanberis stock six times, and the Cesarea and Madryn stocks four and three times respectively. The boxed Scotch seed was replicated five times, but two rows occurred in the same series (No. 7).

In the " Great Scot " trial the Pwllheli, Trawsfynydd and Scotch seed appeared in all five series, Madryn in four and Llanberis and Cesarea in three. There were five replications of the boxed Scotch seed, two in series 4 and three in series 5.

The " Arran Chief " trial was a simple test of Scotch and Trawsfynydd seed, so they were planted alternately in six rows in two series, the order of the planting being reversed in the second series. Each complete variety trial was surrounded by two rows of the same variety, as far as possible, so as to eliminate marginal effects.

Methods used to determine Results.

(*a*) Incidence of virus diseases :—Careful notes of the health of each plant were taken during the growing season and the per cent. infection of each row with virus diseases was tabulated for future reference. (*b*) Yield records :—Owing to the very adverse weather conditions in October, it was impossible to lift all the series in one or two days, and this, of course, rendered the yields liable to an error due to the varying condition of the tubers when lifted. This error was reduced by lifting all the plots in any one series in one day, removing the adhering soil and weighing at once. In this way the yields of the various stocks within a series were directly comparable. As a further precaution alternate series were lifted in one day and the intermediate ones the following day, if the weather conditions permitted.

A comparison of yields was made in three different ways, with substantially the same result :—(1) The mean yields of all the replications of each stock were compared directly. (2) The yield of the Scotch seed in each series was taken to = 100 and the yields of the various Welsh stocks were corrected to this standard. (3) The mean yield of all the plots in a series (containing all the different stocks) was taken to = 100 and the individual plots reduced to this standard. The two latter methods are preferable, since they eliminate the effect of the prolonging of the lifting period as well as errors due to varying soil conditions. Finally, the third method was adopted, since it gave the lowest experimental error.

Yield Results.

The mean yield per plot of sixty tubers of each stock is recorded in Table I, together with the experimental error, the per cent. infection with virus diseases and the per cent. number of " misses " in the rows.

TABLE I.

STOCK.	KERR'S PINK.				GREAT SCOT.				ARRAN CHIEF.			
	% *Misses*	% *V.D.*	*Yield* (*lbs.*)	±	% *Misses*	% *V.D.*	*Yield* (*lbs.*)	±	% *Misses*	% *V.D.*	*Yield* (*lbs.*)	±
Scotch (boxed)...	3.3	1.7	102.7	2.5	2.0	0.3	104.8	1.7	—	—	—	
Scotch (unboxed)	1.0	0.7	105.3	1.3	16.0	0.0	96.5	1.3	2.8	2.5	122.5	3.3
Trawsfynydd	2.3	23.5	95.8	3.9	3.7	18.9	84.7	1.7	4.2	79.1	77.5	2.6
Pwllheli	1.2	4.6	100.1	1.8	1.0	1.0	107.3	2.4	—	—	—	
Brynengan..	1.7	3.6	96.5	2.6	—	—	—		—	—	—	
Llanberis ..	3.3	12.6	97.7	1.4	2.2	3.3	106.2	0.7	—	—	—	
Cesarea.. .	2.5	10.8	98.2	2.6	5.5	7.0	100.6	2.1	—	—	—	
Madryn	6.2	8.9	101.6	4.4	2.5	0.0	104.7	3.7	—	—	—	

NOTE.—For the sake of those unfamiliar with the meaning of the phrase " Experimental Error " or " Probable Error," it may be explained that the figures following the yield represent the error, in lbs., to which that yield is liable, e.g., the figures 2.5 following the yield of the boxed Scotch Kerr's Pink implies that if the trial were repeated under similar conditions there would be even chances that the yield obtained would lie between 105.2 lbs. and 100.2 lbs.

In comparing the yields obtained from these stocks the usual assumption has been made that a difference in yield amounting to three times the probable error of the difference of the means is a real one and not one due to chance. In other words, the odds are 22 to 1 that a similar result would be obtained if the trial were repeated under the same conditions. By this means the yield from the Scotch seed has been compared in turn with that obtained from each of the similarly treated Welsh stocks, with the following results :—

Kerr's Pink. With the exception of the yields from the Brynengan and Llanberis stocks, which were definitely lower than that obtained from the Scotch seed, there was no evidence from this trial that any stock was better than another; such differences as did occur might quite easily have been a matter of chance.

Great Scot. In this variety the yields from the boxed Scotch seed and from the Pwllheli and Llanberis stocks were definitely better than the Scotch seed, which—like all the Welsh stocks—had not been boxed before planting. The Cesarea and Madryn stocks gave quite as heavy a crop as the similarly treated Scotch seed, but the seed from Trawsfynydd gave a definitely lower yield. On the other hand, the Pwllheli stock proved superior to the similarly treated Scotch seed and yielded as well as the Scotch seed, which had had the additional advantage of being boxed to facilitate sprouting.

Arran Chief. There can be no doubt that the Trawsfynydd seed was poorer in cropping power than the Scotch seed in this

variety, the difference in yield being more than five times the P.E. of the difference of the means.

In arriving at these results, no allowance has been made for the occurrence of misses in the rows, since these give some indication of the vigour of the stock and therefore of its suitability for use as seed. The low yield of the unboxed Scotch "Great Scot" seed is undoubtedly largely due to the high percentage of "misses".

So far only the total crops produced have been considered, but in assessing the value of the various stocks an almost equally important consideration is the proportion of saleable tubers in the crop. When potatoes are grown for the table the saleable tubers include all the large ones, or "ware", and some of the larger "seed", whereas to the seed producer the most valuable tubers are those which will pass through a 1¾ or 2 inch square mesh and are retained by a 1¼ inch square mesh. In the present trials the tubers were sorted by hand before weighing into ware, seed, and chats, and Table II gives in each stock the percentage of ware and of ware plus seed obtained.

TABLE II.

STOCK.	KERR'S PINK.				GREAT SCOT.				ARRAN CHIEF.			
	% *Ware.*	±	% *Ware-Seed*	±	% *Ware*	±	% *Ware-Seed*	±	% *Ware.*	±	% *Ware-Seed*	±
Scotch (boxed)	63.4	1.2	91.7	0.8	76.0	0.6	92.6	0.3	—		—	
Scotch (unboxed) ...	50.4	1.5	84.6	0.8	60.6	2.8	87.7	0.9	55.8	1.0	85.7	1.2
Trawsfynydd	39.8	2.2	80.5	1.4	53.0	2.4	82.8	1.1	48.9	1.4	78.0	0.8
Pwllheli............	49.3	2.2	84.9	1.4	60.0	2.8	87.3	1.2	—		—	
Brynengan	48.6	2.8	82.9	1.7	—		—		—		—	
Llanberis	63.4	1.2	89.0	0.9	58.2	2.3	87.1	0.7	—		—	
Cesarea	57.9	2.1	88.2	1.3	57.9	1.3	84.1	1.1	—		—	
Madryn	54.5	2.4	84.7	0.9	63.0	1.2	80.8	0.7	—		—	

On the assumption that, to be significant, any difference between stocks must be at least three times as great as the P.E. of the difference of the means, it is possible to draw the following conclusions from the data given in Table II :—

Proportion of Ware only. In the variety "Kerr's Pink" the proportion of ware to the total crop was not significantly different in the unboxed Scotch seed and the similarly treated Welsh stocks from Pwllheli, Brynengan, Cesarea and Madryn. It was definitely larger in the boxed Scotch seed and the unboxed Llanberis stock, and smaller in the Trawsfynydd seed. In the variety "Great Scot" the Scotch seed gave approximately the same proportion of ware in the total crop as all the Welsh stocks, but significantly less than the boxed Scotch seed, whilst the Trawsfynydd stock of "Arran Chief" was definitely poorer in this respect than the Scotch stock.

Proportion of Ware plus Seed. The *boxed* Scotch seed of both " Kerr's Pink " and " Great Scot " gave a significantly higher proportion of ware plus seed in the total crop than any of the unboxed Scotch or Welsh stocks except the " Kerr's Pink " from Llanberis and Cesarea. The differences shown in the unboxed stocks were not large enough for one to be sure that they were not due to chance, except in the case of the Llanberis stock of " Kerr's Pink ", which was definitely better in this respect than the similarly treated Scotch seed, and the Trawsfynydd " Great Scot ", which had a smaller proportion of ware plus seed than the unboxed Scotch stock. Similarly the Scotch " Arran Chief " was distinctly superior in the production of ware plus seed than the Trawsfynydd seed.

Incidence of Virus Diseases.

Reference to Table I will show the extent to which each stock developed virus diseases during the growing season. In the variety " Kerr's Pink " the Trawsfynydd stock was rather heavily infected, the seed from Llanberis, Cesarea and Madryn (all of which had been grown one year at Madryn) were diseased to a less extent, whilst the remainder were relatively free from infection. Similarly in " Great Scot ", the Trawsfynydd seed was most infected, Cesarea less so and the remainder almost or quite free from disease.

The total virus infection in these two varieties consisted almost entirely of leaf-roll, mosaic, or a combination of the two, the only exception being the Madryn " Kerr's Pink " with 1.2% crinkle and the Trawsfynydd " Great Scot " with 0.7% crinkle. It may seem difficult at first sight to harmonise the statement that virus diseases are mainly responsible for loss in yield from home-saved seed, with the fact brought out in Table I that 28.5% of disease in the Trawsfynydd " Kerr's Pink " led to no significant loss in yield. The explanation is to be found in the relatively high probable error, and in the fact that only 10.0% of the plants were infected with leaf-roll, either alone or in combination with mosaic, whilst 18.5% were affected with mosaic alone—a disease which has far less effect on the yield in most varieties than has leaf-roll. Similarly the Llanberis, Cesarea and Madryn stocks of " Kerr's Pink " had only 0.6%, 1.8%, and 2.8% respectively affected with leaf-roll, or leaf-roll plus mosaic, the remainder of the virus infected plants showing only mosaic symptoms. The facts are quite different in the case of the variety " Great Scot ". Here the Trawsfynydd stock had 9.5% of plants affected with leaf-roll out of the

total 18.9% virus infection. Similarly, of the total 7.0% disease in the Cesarea stock 4.1% was leaf-roll and 2.9% mosaic.

The "Arran Chief" results are particularly interesting from this point of view in that the Trawsfynydd stock of this variety was heavily infected with a number of virus diseases. Here the total 79.0% infection included 6.7% leaf-roll alone, 42.0% mosaic, 11.0% crinkle, 14.4% leaf-roll with mosaic, 0.8% leaf-roll with crinkle, 2.0% marginal leaf-rolling mosaic, and 1.4% curly dwarf. Very little is known as yet about some of these diseases, and even the characters by which they are separated from each other are ill-defined. In the variety "Arran Chief" especially, this is true of the two diseases mosaic and marginal leaf-rolling mosaic. In the typical mosaic plant a diffused mottling of light and dark green areas occurs on the surface of the leaf, together with a definite undulation and paling of the margin. These symptoms are also present in the marginal leaf-rolling mosaic plant, but in this case the margin is also curled upward so that the leaf becomes spoon-like. The special difficulty lies in the occurrence of all stages between the two extremes, sometimes even in the same plant, and in the fact that the rolling of the margin appears to be affected in some way by the season, so that the progeny of a crop which showed marked rolling may exhibit mosaic symptoms almost exclusively. The same lack of distinction between mosaic and marginal leaf-rolling mosaic is to be seen in the variety "Katie Glover"; and in both varieties the diseases—unlike the mosaic of most other varieties—show excessive accumulation of starch in the margin of the leaf. This suggests a closer relationship with leaf-roll than with the mosaic of other varieties and a consequent increase in the importance to be attached to mosaic infection in at least these two varieties.

Discussion of Results.

The object of these trials was to test the potentiality of selected centres for seed potato production. This depends upon two factors mainly : the maintenance of yield as compared with good stocks from outside Wales, and freedom from virus diseases. The latter is, of course, of importance in that the seed would be distributed to localities in which the diseases spread rapidly.

During the growing season the stocks presented the appearance of a very level and uniform crop, as can be seen from Figs. 1 and 2 of the plate.

From the point of view of yields, the results—which are summarised in Table III—are distinctly encouraging as regards the Llanberis "Great Scot", and in both "Great Scot" and

FIG. 1.

1 2 3

WELSH SEED, KERR'S PINK.

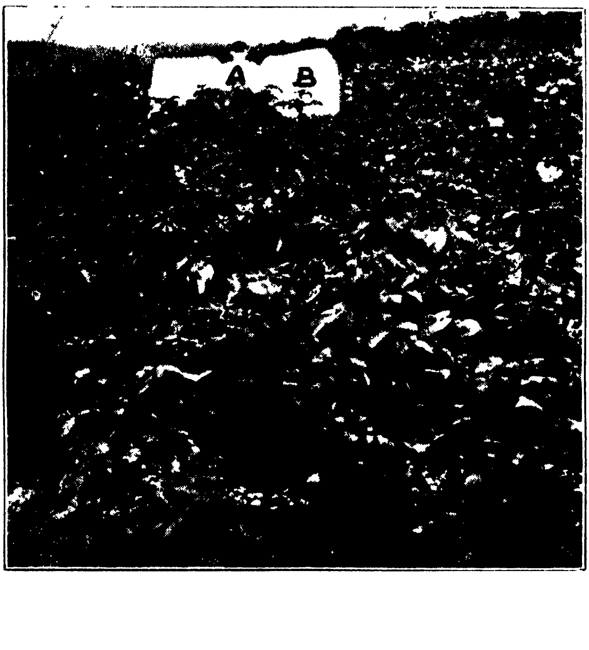
FIG. 2.

4 5 6 7

WELSH SEED, KERR'S PINK.

FIG. 3.

FIG. 4.



" Kerr's Pink " from Pwllheli and Cesarea. The Brynengan " Kerr's Pink " and the Trawsfynydd " Great Scot " and " Arran Chief " definitely fail to reach the Scotch standard, and even the " Kerr's Pink " from Trawsfynydd is probably only saved from a like criticism by the relatively high probable error in the yield of this stock.

TABLE III.

Yields of the various stocks as compared with Scotch seed.

	Kerr's Pink.			Great Scot.		
	Total Yield	*% Ware.*	*% Ware-Seed*	*Total Yield*	*% Ware.*	*% Ware-Seed*
Boxed Scotch	equal	higher	higher	higher	higher	higher
Trawsfynydd	equal	lower	equal	lower	equal	lower
Pwllheli	equal	equal	equal	higher	equal	equal
Brynengan	lower	equal	equal	—	—	—
Llanberis	lower	higher	higher	higher	equal	equal
Cesarea	equal	equal	equal	equal	equal	equal
Madryn	equal	equal	equal	equal	equal	equal

Note.—The Trawsfynydd stock of Arran Chief gave a lower yield in every respect than the Scotch stock.

The position is a little more difficult to assess from the point of view of virus infection. Clearly, however, the Pwllheli result shows that transmission must be extremely slow in that area. This grower would have derived no advantage by changing his seed; indeed, he incurred some risk in 1926 by purchasing Scotch seed of another variety, which proved to be highly infected with " crinkle ". Transmission must also have been slow at Brynengan, since only 3.6% of a susceptible variety like " Kerr's Pink " was infected after five years' cultivation. As regards the Trawsfynydd stock, the writers do not consider the figures to indicate a rapid spread of the disease; at any rate a much higher percentage would probably have occurred in most areas, e.g., the College Farm at Aber, after five years without change of seed. It seems probably that thorough rogueing out of diseased plants, and lifting for seed as early as possible would have greatly improved the value of these stocks for seed purposes. The Cesarea and Llanberis stocks undoubtedly suffered by their one year stay at Madryn. They were only slightly affected in the field at Madryn in 1926 and the Scotch seed alongside was healthy, yet in the following year at Aber 9.0% of the Scotch plants were diseased and the Welsh seed infection had increased to 11% or 12%. This agrees fairly well with a transmission experiment at Madryn previously reported upon (1), in which diseased plants introduced into a healthy plot transmitted leaf-roll to 15% of the latter plants—a much smaller infection than occurred at any of the other centres at which the experiment was carried out.

Two other points deserving of notice were brought out by these trials. (1) The value of boxing seed potatoes is evident from the fact that the boxed seed, obtained from the same source in Scotland as the unboxed, produced a distinctly smaller proportion of small, unsaleable tubers, and in the variety " Great Scot " a heavier total yield than the latter. Not least amongst the advantages of Welsh grown seed potatoes would be the possibility of early delivery of seed and the consequent encouragement of " boxing ". (2) The opinion is sometimes expressed that new Scotch seed tends to produce a smaller quantity of " ware " than once-grown seed, and this is advanced as an argument against renewing the whole stock of seed in any one year. There is reason to believe that this is only true when the home-saved seed has been boxed, a conclusion which is borne out by these results, for the unboxed Madryn seed (which had been moved only some thirty miles) produced no more ware tubers than the unboxed Scotch seed, and both were inferior in this respect to the boxed Scotch stock.

Assuming in all cases suitable conditions for potato culture, seed producing areas would fall into one or other of the following categories :—(1) Areas which are either free from virus diseases or insect carriers, or in which transmission is extremely slow so that by suitable precautionary methods seed stocks could be maintained indefinitely. (2) Areas in which transmission, although slow, is yet sufficiently marked as to necessitate restocking at longer or shorter periods from other sources, even when every effort is made by rogueing, early lifting or other means to prevent degeneration. (3) Areas in which only known resistant varieties could successfully be grown for seed.

It can scarcely be expected that many localities exist in North Wales in which seed can be maintained indefinitely without the exercise, on the part of the grower, of precautions to prevent the introduction of disease or its subsequent spread to healthy plants. Rogueing out diseased plants as soon as they can be recognised may suffice on farms falling in category one, but will certainly not be sufficient on farms falling in either of the other two categories. In the latter cases the diseases are likely to spread to healthy plants before the diseased ones can be recognised and removed, so that other steps must be taken. It has been shown by the senior writer (2) that by lifting the stocks intended for the following year's stock seed as early in the season as practicable it is possible to maintain a high standard of health in the crop. This is illustrated by Fig. 3, which shows the effect of lifting early (July 23rd) some healthy plants (Row A) of a

stock of "Kerr's Pink" grown continuously on the College Farm since 1920 and having at the time of the experiment 82% of virus diseases present, Row B being the crop from unselected seed lifted in October. Similarly Fig. 4 shows the improvement achieved in a stock of "Kerr's Pink" maintained since 1921 and having, in 1926, 45% of the plants infected, A representing the early lifted healthy plants, and B, unselected seed lifted in October.

It is partly with a view to determining into which of these categories certain areas—apparently suitable for seed potato production—fall, that the larger scheme mentioned at the beginning of this account has been put into operation. If adequate supervision can be assured, the discovery of areas falling even in the third category will be of considerable benefit to Welsh potato growers.

The writers desire to express their indebtedness to Professor R. G. White for the interest he has taken in this work and for criticism of the results obtained. Acknowledgments are also due to Mr. Morris Roberts for assistance in planting and lifting the crops.

Summary.

1. An account is given of experiments designed to test the value, as seed, of certain stocks of Welsh potatoes which had been grown for a number of years (up to fourteen) without change of seed.
2. Chequerboard trials, which included new Scotch seed, showed that in several instances the Welsh seed cropped as well as that from Scotland, and in two cases gave heavier yields than the latter.
3. With the exception of seed from one centre, all the Welsh stocks gave at least as high a proportion of ware, and ware plus seed, as did the similarly treated Scotch stocks.
4. The total percentage virus infection in some of the Welsh stocks was considerably greater than in the new Scotch seed. Most of this infection, however, consisted of common mosaic, which had little or no effect on the yields. Having regard to the length of time during which the Welsh stocks had been grown, and the fact that in most cases there had been no supervision or inspection of the crops, the opinion is expressed that the spread of disease on these farms must have been sufficiently slow to justify the belief that healthy seed stocks could have been maintained by such means as

rogueing out diseased plants, and lifting tubers from healthy plants intended for seed, as early as practicable in the season.

5. In the writers' judgment the trials show that good seed potatoes can be grown in selected localities in North Wales.

LITERATURE.

1. WHITEHEAD, T. Some Experiments on Potato Leaf-Roll Transmission in Wales. This *Journal*, Vol. I, 1925, p. 184.

2. ———— Experiments on the Control of Potato Leaf-Roll. This *Journal*, Vol. III, 1927, p. 169.

EXPLANATION OF ILLUSTRATIONS.

FIGS. 1 AND 2. General View of Welsh Seed Trials, 1927. Series One in foreground.

1, Madryn. 2, Scotch. 3, Trawsfynydd. 4, Llanberis. 5, Pwllheli. 6, Brynengan. 7, Cesarea.

FIGS. 3 AND 4. Illustrating the improvement in vigour obtained by lifting tubers from healthy plants early in the season.

FIG. 3. Kerr's Pink grown since 1920 and having, in 1926, 82% of virus disease infection. A. Crop grown from tubers of healthy plants lifted on July 23, 1926. B. Crop from unselected tubers lifted in October, 1926.

FIG. 4. Kerr's Pink grown since 1921 and having, in 1926, 45% virus disease infection. A. and B. as in Fig. 3.

EXPERIMENTS ON THE CONTROL OF FINGER AND TOE IN CABBAGES BY THE USE OF MERCURIC CHLORIDE AND OTHER SUBSTANCES.

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Introductory.

From the standpoint of the allotment holder and market gardener the problem of controlling Finger and Toe disease, due to *Plasmodiophora Brassicae*, is one of equal urgency and perhaps even greater difficulty than that with which a farmer has to contend when dealing with the same disease. It usually happens that the smaller grower with less land at his disposal is unable to adopt any really satisfactory rotation of crops, and has to rely largely upon the use of lime. The value of this to him, however, even though it may serve to some extent to keep the disease in check, is considerably lessened owing to the lapse of

time necessary before any appreciable effect is produced. The experiments here described were planned with the circumstances of the vegetable grower rather than those of the farmer especially in mind, the chief aim being to devise some comparatively simple and at the same time economic method whereby Finger and Toe might successfully be controlled where it is necessary to grow successive crops on the same land year after year.

The work was started in 1924 on the Harper Adams College Farm, where a plot of land was selected on a field notoriously infested with the Finger and Toe organism. In the previous year the field had carried a very badly diseased crop of swedes, the attack over the particular spot chosen being of such severity that the plants upon it were a complete failure.

Determination of Distribution of the Organism.

Although the land selected was known to be heavily infected, it was decided at first to determine as far as possible to what extent the parasite was evenly distributed in the soil, in order to avoid possible errors due to any more or less uncontaminated areas within the plot itself. For this purpose the entire plot was cropped with a mixture of Rape and Mustard, and careful counts were made to determine the percentage of plants with infected roots present. It was found that infection was sufficiently even throughout the area for all practical purposes, a uniform 70% of the plants having diseased root systems.

First Series of Trials, 1925.

The first series of trials was laid down in the summer of 1925. Healthy plants of Autumn Market cabbage and Early London cauliflower were raised for the purpose in sterilized soil.

The infected area was cultivated in the ordinary way along with the remainder of the field; no artificial manures were applied, but a light dressing of farmyard manure was given.

The area was divided up into twenty-five plots each 15ft. long by 10ft. wide, separated by paths 2ft. in width. Five of these plots served as controls, the plants upon them undergoing no treatment. The arrangement of the plots and the positions of the controls are shown in the diagram (Fig. 1).

Owing to various circumstances it was impossible to plant out the seedlings until the last week of June, by which time a prolonged spell of dry weather had rendered the ground so hard that the holes required had to be dug with a trowel, as the dibble would not penetrate the surface.

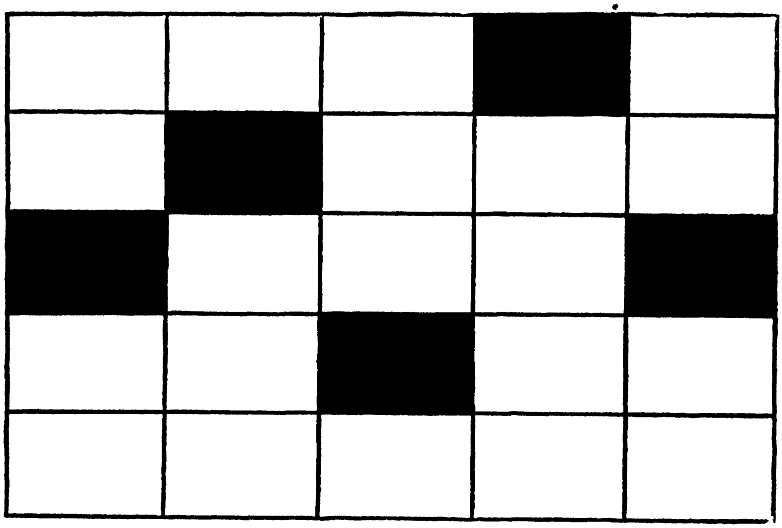
The plants were set in rows of eight, each plot accommodating eleven such rows set parallel to its shorter side. The distance between the rows was 15in., 12in. being allowed between the

plants in each row. Such close planting was not conducive to the most satisfactory growth, and in subsequent trials more room was allowed.

The various chemical substances employed in these tests were used in solution in water, the general procedure being to " puddle in " the plants with about half a pint of the required solution, every plant in each plot receiving exactly the same treatment. The five control plots were planted up similarly, except that the " puddling in " was done with plain water only.

Planting was completed on the 27th June, and, though the

DIAGRAM 1.



weather remained hot and dry for several days, the majority of the plants did not appear to suffer. A fortnight later, after rain had fallen, a small quantity of nitrate of soda was applied to each plant in every plot.

The effect of the following solutions was tested, at least two separate plots (i.e. 176 plants) being allocated to each :—

Methyl Green	0·005%
Malachite Green	0·005% and 0·01%
Methylene Blue	0·005% and 0·01%
Formalin (commercial) ...	0·5% and 0·2%
(equivalent to 0·2% and 0·08% Formaldehyde).	
Lysol	0·2%
Mercuric Chloride	0·1%

The three organic dyes were included because Schmidt (1) has shown that certain coal-tar dyes, particularly Malachite Green, Brilliant Green and Methyl Violet, are extremely toxic, even in very dilute solution, towards micro-organisms, and it was thought worth while to ascertain whether such substances were

likely to prove of any use as fungicides in this particular connection. Brilliant Green and Methyl Violet could not be included in this first test, but were used in subsequent trials as described later.

The plots were examined at intervals during the growing season and notes made as to their general appearance and the condition of the individual plants.

It was soon evident that the treatment with Formalin and with Lysol had been too drastic, as the majority of the plants thus treated wilted rapidly and these plots had to be counted as failures. It may be mentioned, however, that in a preliminary test with plants in pots, it had been found that seeds watered with a 0.2% solution of Lysol would develop healthily though their germination was greatly retarded.

A marked stimulation of growth was observed on the plots where Methyl Green, Malachite Green and Mercuric Chloride had been applied. With the two dyes, however, this effect gradually became less marked, until after a lapse of three of four weeks little difference was found between these plots and the controls. The effect of the Mercuric Chloride, on the other hand, was much more persistent, the plants treated with it clearly remaining the most flourishing of all throughout the season.

On November 2nd the plants were cut, and the produce of each plot weighed separately. The following day the stumps were pulled up and the roots on each plot grouped into four classes according to the extent of disease which they showed. Unfortunately, owing to the trodden condition of the ground, it was not possible to collect every particle of root, but, on most of the plots, at least two-thirds of the total number was available. The roots were classed as: (1) "Bad," where the entire main and lateral system was involved; (2) "Moderate," where clubbing was confined to either main or lateral roots only; (3) "Slight," where, apart from a few isolated swellings, usually at the extremity of the lateral roots, the whole root system was well developed; (4) "Free", where no clubbing was discernible.

TABLE I.

Treatment.	*No. of ... Plots.*	*Extent of Clubbing.*		*Weight per head.*	
		Bad and Moderate.	*Slight or Free.*	*Cauli-flower.*	*Cabbage.*
				lb.	lb.
None ...	5	97%	3%	1·1	2·1
Methyl Green ...	4	88%	12%	1·6	2·2
Malachite Green ...	3	95%	5%	1·7	1·6
Mercuric Chloride ...	2	66%	34%	2·0	2·8

Table I, above, shows the actual figures obtained from the three most effective treatments together with those given by the control plots, and the results obtained from the whole experiment may be summarised as follows :—

1. Mercuric Chloride...	Growth stimulated and markedly improved. Weight increased by an everage of ¾lb. per head. Clubbing, exclusive of " very slight ", reduced by 30%.
2. Methyl Green ...	Growth stimulated in early stages. Effect on weight and extent of clubbing negligible.
3. Malachite Green ...	Similar in effect to Methyl Green. No ultimate, improvement.
4. Formaline 5. Lysol	Too drastic as applied. Plahts checked and many killed.

Second Series of Trials, 1926.

This series of trials was carried out on the same plots as before. While the experiment this year was similar in the main to the previous one, certain alterations in procedure were made in order to obtain better control and greater uniformity. In all but four of the plots, the treatment of which will be described later, the plants were set out in nine short rows, arranged as before and comprising seven plants each, thus allowing some 18in. between the plants each way. Of these nine rows, only six received treatment, the remaining three, i.e. twenty-one plants in each plot, being left as controls.

The young healthy plants were again " puddled in " with about half-pint of the solution to be tested, except in two plots, where the material was employed in the form of a sludge.

In view of Wähling's (2) results with Carbolineum, a method of soil treatment prior to planting was tried on the four remaining plots. Here one half of each plot was dressed, on the 24th March, with a solution of Carbokrimp. Six gallons of a 5% solution of this " tar oil " were evenly distributed over two of the plots, while the other two received an equal quantity of a 10% solution. The remaining halves of each of these four plots were left untreated. Healthy cabbage seedlings, raised in sterilised soil, were planted on these plots on the 20th May without further treatment of the soil or of the plants. In the remaining twenty-one plots planting was done during the first week of June. Cabbages only were used, obtained from a disease-free area in Middlesex. Owing to a serious attack by the Cabbage-Root Maggot, which practically decimated all the plots about ten days after planting, it was found necessary to re-plant them on June 28th, care being taken in no way to vary the positions of the control rows. Besides the soil treatment with Carbokrimp already

described, tests were carried out with the following :—

Mercuric Chloride ... ... 0·1% and 0·2%
Uspulun ... ... 0·25% and 0·5%
Brilliant Green ... ... 0·01% and 0·02%
Methyl Green ... ... 0·005% and 0·02%
Methyl Violet ... ... 0·01%
Malachite Green, used as a sludge.
Cheshunt Compound, 1¼ ozs. in three gallons of water.
Clubicide, a proprietory article of a cresylic nature.

TABLE II.

Treatment.	*No. of plots.*	*No. of plants set.*	*Average weight per head. lbs.*	*Extent of Clubbing.*		
				Bad and moderate.	*Slight and absent.*	*None visible.*
None ...	11	231	1·0	94%	6%	0·5%
Mercuric Chloride	3	126	3·3	23%	77%	27%
Uspulun* ...	3	126	1·9	65%	35%	0
Clubicide ...	2	84	1·4	77%	23%	2%
Brilliant Green*	3	126	1·7	75%	25%	2%

* The Uspulun and Brilliant Green figures include both the strengths at which these substances were used, there being no appreciable difference between the effects of the stronger and weaker solutions.

The figures given in Table II are the averages of the results obtained with each of the four most effective substances, together with those given by the corresponding untreated rows of plants. The most marked improvement was again observed where Mercuric Chloride had been used, whilst Uspulun also produced a distinct, but less beneficial, effect.

Of the other substances, Clubicide and Brilliant Green alone proved of the slightest use in controlling the disease and that to a very feeble degree.

Prominent in the above Table is the very considerable increase in weight of the plants treated with Mercuric Chloride as compared with that of the adjoining untreated plants, but only some 27% of these vigorous plants proved to be completely free from the disease, though the condition of their roots suggested that they had been attacked only at a comparatively late stage. Such late infections might arise either from spores which had been able to withstand the toxic action of the Mercuric Chloride, or perhaps through the extension of the roots beyond the region disinfected. Later attempts to obviate these infections by subsequent applications of the fungicide are described below.

Third Series of Trials, 1927.

Owing to the promising results obtained with Mercuric Chloride attention was mainly concentrated upon this substance

in 1927. In addition to plots in the three West Midland counties, arranged for by the writer, trials were carried out at the suggestion of Dr. Whitehead of Bangor, at a number of centres in Wales where Finger and Toe disease was particularly prevalent; and altogether trials were laid down in eleven different counties, viz., Warwickshire, Staffordshire, Shropshire, Flint, Denbigh, Caernarvon, Anglesey, Carmarthen, Cardigan, Pembroke and Glamorgan.

For the sake of convenience the trials carried out in Shropshire, at the Harper Adams College, will be dealt with first.

(*a*) *Experiments carried out at Harper Adams College.*

A different piece of land from the one previously occupied was used. Care was taken, however, to ensure that soil infection was uniform throughout.

The plots were, for the sake of convenience, laid down end to end, each plot being 40ft. long and 18ft. wide. The planting distances were 2ft. apart between the rows, and 1½ft. between adjoining plants in the row.

Each plot consisted of eight long rows, each carrying twenty-five plants. The plants in the outermost row on either side of each plot were left untreated as controls, the two pairs of rows adjoining these carried treated plants, while the two central rows were again left as controls. Numbering the rows from one to eight the arrangement in each plot may be expressed as follows :—

Controls :	rows	1,			4,	5,			8
Treated :	rows		2,	3,			6,	7,	

In certain plots, this arrangement was reversed in order to break the continuity of the control and treated rows, and so improve the distribution of the control plants over the whole area involved.

The plants used were healthy cabbage seedlings, variety Ellam's Early, obtained from a locality in the north of Shropshire, and raised on land that had previously been permanently under grass. The seedlings were pulled as required and in no single plant was there any sign of the disease.

Except on the single plot where Mercurous Chloride was applied the mode of treatment was essentially similar to that adopted before.

Tests were carried out with the following substances :—

Mercuric Chloride—0·05%, 0·1% and 0·2% solutions.
Mercuric Chloride with Chlorophenol—Solution containing 0·1% of each.
Uspulun—0·25% and 0·5% solutions.
Mercuric Nitrate—0·1% solution.
Mercurous Chloride—Applied dry.

With Mercuric Chloride 0.1% and 0.05%, in addition to the usual treatment at the time of planting, a second application was given on two of the plots some twelve weeks after the first. This was done to find whether the later infections, noted in the preceding year, could thus be prevented. All the other solutions were applied once only at the time of planting. Treatment with Mercurous Chloride consisted in dipping the roots of the seedlings into the dry powdered chemical immediately before setting.

As before, the appearance of the plots was noted from time to time and the total weight of produce from each row was recorded. The plants were not all cut at the same time, however, but as they matured and would have been cut for market in the ordinary course. After cutting, the roots were examined and grouped according to the extent of clubbing present.

The results obtained are shown in Table III, and are discussed in a subsequent section.

(*b*) *West Midland and Welsh County Trials.*

In these trials, with the exception of one centre in Warwickshire and one in Staffordshire, the seedlings were obtained from the same source as that already mentioned, and the arrangement of the plots and method of treatment was essentially similar to that previously adopted.

The only substance tested was Mercuric Chloride 0.1% concentration, one, two and three applications being given.

The planting, treatment and subsequent weighing and examination of the plants was carried out under the supervision of some responsible person, generally the County Horticultural Instructor.

The results obtained from those centres which furnished full data are given in Table 4. Observations made at the remaining centres, from which, owing to various local difficulties, only incomplete data could be obtained, are mentioned in the text.

Discussion of Results.

1. *Effect of Mercuric Chloride upon growth.*

As has already been noted, in 1925 and 1926 the growth of the plants receiving Mercuric Chloride solution appeared to be stimulated from the outset, and these plants maintained an ascendency over the controls throughout the season.

TABLE III.

Finger-and-Toe Control Trials at Harper Adams College, Shropshire. Third Series, 1927.
Effect of Treatment of Cabbage Seedlings with various Substances.

Note.—Figures in third column refer to total number of plants set, one-half this number being treated and half untreated.

Number of Applications.	Substance Tested and Concentration.		No. of Plants Set.	Date of 1st Treatment and of Planting.	Date of 2nd Treatment.	Total Weight of Crop. lbs.		Average Weight per Head. lbs.		No. of Plants Failed.		Extent of Clubbing of Roots. Bad and Moderate % No. of Roots.		Slight or Absent % No. of Roots.		No Clubbing % No. of Roots.	
						Treated	*Untreated*	*Treated*	*Untreated*	*Treated*	*Untreated*	*Treated*	*Untreated*	*Treated*	*Untreated*	*Treated*	*Untreated*
One application only at time of Planting.	Mercuric Chloride (alone)	0.05%	104	Mar. 22	—	87	104	1.7	2.0	1	1	38	36	62	64	14	18
		0.1%	200	,,	—	196	117	2.0	1.3	2	12	39	67	61	33	16	8
	Mercuric Chloride with Chlorophenol.	0.05%	200	Mar. 28	—	73	103	0.9	1.3	18	20	92	86	8	14	0	0
		0.1%	200	Mar. 22	—	66	200	1.1	2.1	43	5	88	67	12	33	2	9
	Uspulun.	0.5%	200	Mar. 28	—	163	143	1.8	1.6	8	9	72	81	28	19	2	1
		0.25%	104	,,	—	60	79	1.3	1.6	6	3	93	84	7	16	0	2
	Mercuric Nitrate. 0.1%	Plot 1	104	Apr. 2	—	90	100	1.7	2.0	0	3	25	57	75	43	17	6
		Plot 2	104	,,	—	76	70	1.5	1.5	2	4	36	65	64	35	17	5
	Mercurous Chloride.	Dry	104	Apr. 2	—	114	73	2.3	1.7	2	8	34	71	66	29	29	13
Two applications: at planting and 3 months later.	Mercuric Chloride. (alone)	0.05%	104	Mar. 22	June 20	120	98	2.3	2.0	0	3	30	51	70	49	25	12
		0.1% Plot 1	200	,,	,,	259	223	2.7	2.4	0	0	28	70	72	30	40	9
		0.1% Plot 2	200	,,	,,	243	189	2.4	2.2	2	4	32	50	68	50	36	21
Mercuric Chloride Averages for both Concentrations 0.05% and 0.1% and Corresponding Controls.	for One application only					141.5	110.5	1.85	1.65			38.5	51.5	61.5	48.5	15.0	13.0
	for Two applications					207.3	170.0	2.47	2.2			30.0	57.0	70.0	43.0	33.7	14.0
	for Whole Series...					181.0	146.2	2.22	1.98			33.4	54.8	66.6	45.2	26.2	13.6

In 1927 however, in a number of cases, notably at centres in Shropshire, Warwickshire, Cardiganshire and Flintshire, a distinct check was observed in the growth of the plants treated with this substance, so much so that for the first two or three months the treated rows showed up badly against the adjoining untreated rows. In most cases, however, as the season advanced the growth of the treated plants became more normal and by the time of cutting they had usually come well up to the level of the controls as regards size, and in many cases showed a marked improvement over the latter in this respect.

At the Warwickshire centre, however, the treated plants never appeared to recover properly from the initial check, their growth being poorer than that of the controls up to the end of the season. In Cardiganshire, on the other hand, though their growth was retarded even up to the time of "hearting," the treated plants finally turned to heart more quickly and formed heavier heads than the controls.

On the Pembrokeshire plots the treated plants were reported to have made more rapid growth than the controls from the start.

2. *Effect of the treatment upon the Root System.*

A consistently favourable effect upon the root system of the treated plants was observable at all centres.

In four centres in Glamorganshire a very marked reduction of the disease was noted. At only one of these centres was any appreciable amount of clubbing present on the roots of treated plants, though at each of them the controls were severely affected. At the fourth centre, on very poor gravelly soil, both treated and control plants were attacked, the ultimate effect upon the treated roots being, however, considerably less severe than that noted in the corresponding untreated plants.

In Anglesey also, little or no evidence of infection of the treated plants could be found, while 80% of the controls were diseased, and in Cardiganshire, infection was reduced from 40% to 20% where Mercuric Chloride was applied.

Taking the average for seven plots, comprising centres in Shropshire, Warwickshire, Caernarvonshire and Staffordshire, where a particularly careful examination of the roots was made, a reduction of nearly 40% in the number of badly infected roots amongst the treated plants was found as compared with the controls, and a corresponding increase in the number of clean roots, the actual recorded figures being shown in Table V.

TABLE IV.

Finger-and-Toe Control Trials at various Centres. 1927 Series.
Effect of Treatment of Cabbage Seedlings with Mercuric Chloride, 0·1% Solution.

Number of Applications of Mercuric Chloride 0.1%	County and Place.	Date of 1st Treatment and of Planting.	Date of 2nd and 3rd Treatment.	Total Weight of Crop. lbs.		Average Weight per Head. lbs.		No. of Plants Failed.		Extent of Clubbing of Roots. Bad and Moderate % No. of Roots.		Slight or Absent % No. of Roots.		No Clubbing % No. of Roots.	
				Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
One application only at time of Planting.	Warwickshire, Warwick ..	—	—	110	178	1.7	2.1	1	0	0	29	100	71	91	7
	Staffordshire, Tamworth .	May 25	—		Cauli	flowers,	not weig	hed.		12	71	88	29	88	29
	,, Cannock ...	July	—	65	26.5	M'x'd V	arieties	3	0	32	84	68	16	25	1
	Caernarvonshire, Pwllheli	Apr. 12	—	101.75	57.25	1.47	0.78	2	9	16.3	72.5	83.7	27.5	60.3	14.4
	Pembrokeshire	May 14	—	120.5	43.5	1.5	1.2	20	23	0	46	100	54	81	12
	Average			99.3	76.3	1.6	1.4	—	—	12.1	60.5	87.9	39.5	69.1	12.7
Two applications, at time of planting and 4 to 6 weeks later.	Caernarvonshire, Pwllheli	Apr. 12	May 25	119.75	68.5	1.49	0.96	6	17	2.1	23.0	97.9	77	90.5	54
	Carmarthenshire, Centre 1	Apr. 12	May 1[illegible]	75	52.5	2.5	1.75	—	—	0	100	100	0	0	0
	,, ,, 2	,,	,,	90	52.5	3.0	1.75	—	—	0	100	100	0	0	0
	Average			94.9	57.8	2.3	1.5			0.7	74.4	99.3	25.7	30.2	18
Three applications, at planting, 4–6 weeks later, and 1 month after that.	Staffordshire, Shenstone .. A few plants treated *once only* included.	Apr. 8		—	—	—	—	0	— 45% did not mature	0	78	100	22	87	0

TABLE V.

Effect of Treatment with $HgCl_2$, 0·1%, on extent of Clubbing and Crop Weight.

CENTRE.	CONTROLS.			TREATED.		
	ROOTS.		CROP.	ROOTS.		CROP.
	% Badly Clubbed.	*% Not Clubbed.*	*Weight lbs.*	*% Badly Clubbed.*	*% Not Clubbed.*	*Weight lbs.*
Shropshire—3 plots	43 49 37	8 9 21	117 223 189	11 14 10	16 40 36	196 259 243
Warwickshire—1 plot ...	29	7	178	0	91	110
Carnarvonshire—2 plots .	72 23	14 54	57 69	16 2	60 91	102 120
Staffordshire—1 plot* ..	65	1	27	2	26	65
Average of 7 plots (700 treated, 700 controls)..	45	16	123	8	51	156

* Mixed varieties.

8. *Influence of weather conditions upon the results obtained.*

On comparing Tables I, II and III, all of which refer to experiments carried out at the College, it will be seen that the most marked effects with Mercuric Chloride were obtained in the 1926 trials. In that year, the treated plants yielded an average of 70% more clean or but slightly affected roots than did the corresponding controls, while the increase obtained in 1925 and 1927 respectively was only about 30%. A probable explanation of these divergent figures is to be found in the weather conditions prevailing at the time of planting or more especially over a short period subsequent thereto. According to the meteorological statistics available, the rainfall in the College area over a period of eight days subsequent to planting was as follows :—

1925 (June 30th–July 7th) 1·01 ins.
1926 (June 30th–July 7th) 0·48 ins.
1927 (March 22nd–March 30th) 1·04 ins.

Thus, over what may be considered a critical period, more than twice as much rain fell in the years 1925 and 1927 than in 1926. In 1925 the bulk of this occurred on the 8th day after planting, when 0.88in. fell in 24 hours, while in 1927, rain, though less heavy, was more continuous, some falling on each of the eight days in question, 0.2in. being the recorded minimum and 0.26in. the maximum for any one of these days. In 1926 on the other hand, no rain fell until the 6th day after planting, and the maximum in 24 hours for the period was only 0.29in. Similarly where a second application of the fungicide was given in 1927, rain

followed immediately, 1.88in. falling during the subsequent eight days.

Any considerable quantity of rain following upon the application of the fungicide would serve to dilute the latter and perhaps to remove much of it from the sphere of action. Thus, with a wet time after planting one might expect a less satisfactory control than would be obtained under drier conditions. It may of course be argued that the organism would naturally be less active in 1926, owing to the comparatively dry soil conditions then prevailing. If this were so, however, a milder attack of the disease in the control plants might be expected in that same year, whereas, actually, the number of badly infected controls was only 3% below the figure obtained in 1925 and nearly 30% above that of 1927. The actual figures are again inserted here for comparison :—

	1925	1926	1927
Controls badly or moderately clubbed ...	97%	94%	67%
Controls slightly clubbed or clean ...	3%	6%	33%

It may further be noted that untreated plants in a rainy season often form roots above the normal level which enable them to overcome, in a large measure, the effect of the damage done to their main root system, and so to produce better heads than might normally be expected. This might account in some measure for such reduction of difference in the weight of the crop yielded by treated and control plants respectively as is discernible between the experiments of 1925 and 1927 and those of 1926.

4. *Effect of Mercuric Chloride at different concentrations, and of other modes of treatment.*

The results of these further experiments, all of which were conducted at the College, have already been recorded in Table III and need but little further comment here.

(a) *Mercuric Chloride 0.5%.*

A single application of this solution produced no beneficial effect. Where a second application was made, however, some reduction of clubbing can be noted together with a slight increase in weight of crop. The significance of these differences, though they are somewhat slight, is increased when it is borne in mind that a wet period again succeeded the application of the solution, and the possibilities of $HgCl_2$ at concentrations below 0·1% would appear to be worth investigation.[1]

[1] Since the completion of this paper it has been noted that Gloyer and Glasgow have reported finding a 1 in 2,000 solution of Mercuric Chloride to be effective against Finger and Toe under certain conditions. *Vide* Gloyer, W. O., and Glasgow, H. " Cabbage seedbed diseases and Delphinium root rots: their relation to certain methods of Cabbage Maggot control ". *New York (Geneva) Agric. Exper. Sta. Bull.*, 513, 1924 (Abs. *Rev. Appl. Mycol.*, IV, p. 9, 1925).

(*b*) *Mercuric Chloride 0.2%.*

A very severe check to the young plants was observed here without any reduction of the disease, this result may be compared with the similarly adverse one given by Chlorophenol which caused an even greater check to growth and resulted in the treated plants being seriously attacked.

(*c*) *Chlorophenol with Mercuric Chloride, solution containing 0.1% of each.*

Treatment proved much too drastic, some 60% of the treated plants failing and the remainder being very seriously checked. Clubbing was also considerably worse in the treated plants, a condition comparable with that occasioned by 0.2% Mercuric Chloride.

(*d*) *Uspulun 0.5% and 0.25% solutions.*

No significant differences between the treated and untreated plants. Comparing this result with the marked improvement shown by Uspulun-treated plants in the previous year, this failure may perhaps be attributed largely to weather conditions.

(*e*) *Mercurous Chloride applied dry.*

A distinctly beneficial effect was apparent, though, owing to the comparatively small number of plants treated, too great a reliance cannot be placed upon the figures obtained from this single test. It may be noted that the compound had not been washed away appreciably as it could still be seen adhering to many of the roots pulled up for examination.

(*f*) *Mercuric Nitrate 0.1%.*

Some reduction of clubbing appeared to have been effected but with no corresponding increase in weight of crop.

Conclusions.

From the experiments described it is evident that a considerable measure of control over Finger and Toe disease of Brassicas can be attained by the use of Mercuric Chloride solution. Whether the method so far tested will prove the most satisfactory and economic means of applying this fungicide requires further investigation. That it may become a thoroughly practical method would appear from the test made with it under conditions of actual market-gardening practice. At one centre in Staffordshire (Tamworth), over a thousand cauliflower plants were thus treated by the grower with definitely beneficial results. That no actual weighings were carried out in connection with this particular test is due solely to the fact that no attempt was made to interfere in any way with the ordinary commercial routine.

Under the conditions of these experiments, the cost of the Mercuric Chloride treatment works out at about 6d. or 7d. per 100 plants, or less than 8% of the average value of the crop. The extremely poisonous nature of Mercuric Chloride must of course be borne in mind, but little risk is involved in its use in

the hands of careful and intelligent growers. It can moreover be obtained in the form of tablets of definite weight which obviates the necessity of weighing and lessens the risk involved in its use.

In view of the measure of success so far attained it would seem worth while investigating certain other measures of procedure with Mercuric Chloride, and perhaps with other Mercuric compounds, with a view to eliminating if possible the danger of a serious check to the plants, without at the same time affecting the toxicity of the fungicide.

Kochs (8) claims to have obtained excellent results in the control of Finger and Toe by using certain brands of Uspulun applied to the soils in the dry state. In the form of a solution however this compound has proved, in the tests above described, of distinctly less value than Mercuric Chloride, and under these conditions it is also more expensive to use.

With regard to the use of various toxic dyes it is quite obvious that they are useless against Finger and Toe at the concentrations employed and no further attention need be paid to them.

Acknowledgements.

The author's thanks are especially due to Dr. G. H. Pethybridge for many valuable suggestions and for the practical interest which he has taken in these experiments from their commencement, and to Dr. T. Whitehead, without whose co-operation the extensive series of trials in Wales could not have been organized. He would also gratefully acknowledge the very willing and practical assistance afforded by the Organisers and Horticultural Advisers of the counties already mentioned, and he would heartily thank the various growers, and owners of private gardens, who kindly allocated portions of their land to the purposes of these experiments.

Summary.

Experiments extending over a period of three years in the control of Finger and Toe of Brassicas are described. The efficacy of a variety of chemical substances when applied to cabbage seedlings was tested.

Treatment with Mercuric Chloride, 0.1% solution, proved the most satisfactory and consistently afforded a considerable measure of control. In some instances such treatment checked the growth of the plants to some extent, but this adverse effect was rarely of a lasting nature.

Good, but somewhat inferior results were also obtained with a 0.5% solution of Uspulun.

Certain coal-tar dyes at concentrations up to 0.02% proved quite ineffective in controlling the disease.

Preliminary treatment of the soil with a tar-oil product, Carbokrimp, some weeks previous to planting was also tried, but no conclusive results were obtained.

Further experiments with Mercuric Chloride and other substances are being undertaken.

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"FINGER AND TOE" EXPERIMENTS IN MID-WALES INVOLVING THE USE OF RESISTANT VARIETIES OF SWEDES.

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Turnips and swedes form one of the most important farm crops in Wales. Of the total arable area in 1925 (681,600 acres) 47,410 acres were under turnips and swedes; again in 1926 out of 674,605 acres the area under the crop was 45,109. The relative importance of the crop, in comparison to other crops, is shown in Table I, from which it will be observed that they constituted 6.95 per cent. and 6.68 per cent. of the total arable area in the Principality for the years 1925 and 1926 respectively.

Inasmuch as the root crop plays such a large part in the farming system, it is important that every effort should be made to grow crops free from diseases.

From observations made by the writers in the Mid-Wales province "Finger and Toe" (*Plasmodiophora brassicae*) is apparently increasing in extent and virulence. The disease is so prevalent in some districts that farmers have been unable to grow economic crops and have for some years excluded swedes and turnips from their rotation. Many factors are responsible

for this serious situation. To-day liming is not such a common practice as it was formerly owing to the high price of lime and of labour. This is especially applicable to outlying districts. The lime deficiency is aggravated still further by a marked increase in the use of acidic manures such as sulphate of ammonia and superphosphate. Farmyard manure contaminated with diseased material is an important contributory means of spreading the disease, a fact that is almost totally ignored by farmers. More attention is now given to the growing of other cruciferous crops liable to "Finger and Toe", such as kale, mustard, rape, cabbages and rape and these are often the means of perpetuating the disease from year to year.

A dressing of lime will generally check "Finger and Toe", but in many districts this is not easy to obtain. Consequently other methods of control must be investigated.

Whitehead in 1921[1] and 1922[2] tested the resistance of two strains of swedes of the Danish variety Bangholm. His results seem to indicate a hopeful method of control for the practical farmer. These strains proved less susceptible to "Finger and Toe" than some British varieties. In addition they were superior in dry matter content and were thus assumed to possess a higher feeding value.

The trials reported in the present paper were undertaken with the object of obtaining additional data on the resistance and cropping qualities of these strains and the Øtofte strain of Wilhelmsburger. They have been conducted for the past four years in the Mid-Wales province. The following strains and varieties were included :—

Bangholm Hernig	Danish.
,, Studsgaard	,,
Wilhelmsburger Øtofte	,,
Best of All	British.
Lord Derby	,,
Elephant	,,

The seed for the earliest experiments were obtained from Messrs. McGill and Smith, Ayr, but for the subsequent trials direct from different sources in Denmark. The strains were sown in 1/20 acre plots, Danish alternating with plots of British

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1 Whitehead, T. University College of North Wales, Bangor. Report on Experiments, 1920-21.

2 Whitehead, T. This *Journal*, Vol. I, p. 176, 1925.

varieties. Each plot received the following dressing per acre :—

Farmyard manure	...	15–20 tons.
Sulphate of Ammonia	...	1 cwt.
Superphosphate	...	4 cwt.

The crop on each plot was weighed at maturity and the roots examined for the incidence of the disease. Roots infected with " Finger and Toe " were classified as such and no distinction was drawn between slightly and badly infected ones.

Observations were made at intervals throughout the growing period on the behaviour of the different varieties under different conditions of growth, and their reaction to other fungoid diseases and insect pests.

General observations.

With the exception of the trials carried out in 1926 a good " take " was obtained throughout and very little difference was observed in the germination of the various lots. In 1926, however, the ravages of the Turnip Flea Beetle (*Phylotreta undulata*) during the early growth seriously affected establishment. The few plants that survived were attacked by Swede Midge Fly (*Contarina nasturti*), which made them susceptible to " Neck Rot ". It was, therefore, impossible to make any weighings during this particular year, but some data were obtained at one centre on the relative degree of infection by " Finger and Toe ". The Bangholm strains and the British varieties seemed to have suffered equally from the Turnip Flea Beetle and later from the Swede Midge Fly, but Wilhelmsburger was more susceptible to the latter.

Mildew was very prevalent in some districts in 1925, but the Danish strains proved, as in Whitehead's trials (1), to be less susceptible than the British varieties. Their green foliage stood out prominently against the partly rotted leaves of the British kinds. The capacity of the foreign strains to resist the effect of frost was another important feature of these trials. Moreover, it is the conviction of farmers who have tried them in this area that they are hardier than many of our own varieties. They are also slower in reaching maturity.

Some of the outstanding morphological features of these strains are their differences in shape, size and colour. The Hernig and Studsgaard strains have purplish tops; and, although their shape is variable the tankard type is the most common. Hernig is on the average a smaller root than Studsgaard. Wilhelmsburger is quite distinct from the others in appearance—it is globular, green topped, has smaller leaves, and is far more uniform in type.

TABLE I.

Total acreage of roots and forage crops under arable cultivation in Wales.

Year.	*Total Arable.*	*Mangolds.*	*Per cent. of Total Arable.*	*Potatoes.*	*Per cent. of Total Arable.*	*Turnips and Swedes.*	*Per cent. of Total Arable.*	*Forage Crops.*	*Per cent. of Total Arable.*
	Acres.	Acres.		Acres.		Acres.		Acres.	
1925	681,600	10,759	1·58	23,586	3·46	47,410	6·95	12,318	1·80
1926	674,605	11,190	1·65	23,179	3·43	45,109	6·68	11,723	1·73

TABLE II.

Average yield per acre on infected land.

Centres.	*Bangholm Hernig.*			*Bangholm Studsgaard.*			*Wilhelms-burger.*			*Best of All.*			*Lord Derby.*			*Elephant.*		
	T.	c.	q.	T.	c.	q.	T.	c.	q.	T.	c.	q.	T.	c.	q.	T.	c.	q.
1924.																		
Egryn	23	0	1		—			—		0	0	0		—			—	
Sebonig	25	17	2		—			—		19	0	3		—			—	
Carngadell	16	2	2		—			—		16	15	2		—			—	
Caeffair	10	0	0	10	0	0		—		0	0	0		—			—	
1925.																		
Sebonig	19	7	3	22	2	3	25	19	1	26	1	3	23	4	1	23	18	2
1927.																		
Werngron	15	0	0	16	2	0	14	15	0		—		11	16	0	14	0	0
Average weight p.a.	18	4	1	16	1	2	20	7	0½	12	7	1	17	10	0½	18	19	1

TABLE III.

Average yield per acre on healthy land.

Centres.	*Bangholm Hernig.*			*Bangholm Studsgaard.*			*Wilhelmsburger.*			*Best of All.*			*Lord Derby.*			*Elephant.*		
	T.	c.	q.	T.	c.	q.	T.	c.	q.	T.	c.	q.	T.	c.	q.	T.	c.	q.
1925.																		
Glanrafon	18	3	3	18	15	3	21	3	1	24	8	0	22	2	3	20	16	2
Pandy		—		21	7	0	19	10	2	21	1	3	21	1	3	19	17	3
Penowern	17	12	2	17	15	1	16	4	3	19	7	3	18	8	3	14	13	1
1927.																		
Tynybryn	9	18	0	7	9	0	10	2	0		—		10	11	0		—	
Faildre	12	16	0	15	9	0	14	0	0		—		18	0	0		—	
Average weight p.a.	14	12	2	16	3	1	16	4	0	21	12	2	18	0	3	18	9	0

TABLE IV.

Average degree of infection.

	Bangholm Hernig.	*Bangholm Studsgaard.*	*Wilhelmsburger.*	*Best of All.*	*Lord Derby.*	*Elephant.*
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Egryn	0	—	—	100	—	—
Sebonig	8	—	—	65	—	—
Carngadell	0	—	—	25	—	—
Caeffair	8	9	—	100	—	—
Sebonig	2	5	0	10	50	80
Werngron	6	7	8	—	50	—
Average per cent. infection for all centres	4	7	4	60	50	80

TABLE V.

Average infection of strains obtained from different sources.

	Bangholm Hernig.		*Bangholm Studsgaard.*		*Wilhelmsburger Øtofte.*		*Best of All.*
	Source.	*Per cent. Infection.*	*Source.*	*Per cent. Infection.*	*Source.*	*Per cent. Infection.*	
	No. H1	12	No. S1	30	No. W1	11	34
	No. H2	8	No. S2	20	No. W2	6	—
	—	—	No. S3	17	No. W3	6	—
	—	—	No. S4	14	—	—	—
	—	—	No. S5	9	—	—	—
	—	—	No. S6	6	—	—	—
Average infection ...		10		16		7	34

TABLE VI.

Chemical analysis.

	Bangholm Hernig.	*Bangholm Studsgaard.*	*Wilhelms-burger.*	*Best of All.*	*Lord Derby.*	*Elephant.*
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	89·9	90·49	91·80	91·99	90·30	92·92
Dry Matter	10·1	9·51	8·20	8·01	9·70	7·08
PER CENT. DRY MATTER						
Crude Protein	12·57	13·35	13·29	14·98	12·68	13·70
True Protein	5·34	7·25	7·92	8·48	5·25	7·76
Ash	6·33	7·46	7·80	7·59	6·80	8·47
P_2O_5	·69	·90	1·07	·71	·71	·74
Lime	·66	·75	·79	·68	·70	·81

Results.

A summary of the results in all the trials is given in Tables II to VI. The average weight per acre of the different varieties on infected land, as given in Table II, shows the superiority of the Danish strains over the three British varieties tested. Of the foreign swedes the best average weight per acre was given by Wilhelmsburger, but owing to the recent introduction of this strain it was possible to include it in two of the trials only. The Hernig strain of the Bangholm variety gave a slightly superior yield to Studsgaard. A significant feature brought out in Table II is the complete failure of the variety Best of All at two of the centres. At one of these centres, Egryn, swede growing has been discontinued, but even here Bangholm gave an economic crop where Best of All was a complete failure. The figures obtained in the 1925 trials at Sebonig are much higher than the average results for British varieties on infected land. This is due to the fact that the infection was not virulent during that year. Consequently, the yield per acre does not indicate accurately the incidence of the disease. When these varieties were examined at a later date in the clamps, rotting was much more prevalent amongst the British varieties.

From Table III it will be seen that there is a distinct superiority in average cropping qualities on uncontaminated land in favour of the three British varieties. This is consistently true for individual centres. Wilhelmsburger was again not inferior to the other two Danish strains. Although Bangholm Hernig gave a good comparative yield figure on infected land (Table II), it was distinctly inferior to the same varieties (Table III) when grown on uncontaminated land.

A comparison of the average figures given in Tables II and III shows a higher yield per acre for Danish strains on infected land.

This anomaly is explained by the exceptionally heavy crops grown at Sebonig centre in 1925. British varieties gave a higher yield on healthy land as expected.

An idea of the comparative susceptibility of the different varieties to " Finger and Toe " is given in Table IV. It will be seen that the British kinds sustained a heavy infection at all the centres, even as much as 100 per cent. in some cases. The Danish strains, on the other hand, definitely proved to be much more resistant. The Hernig strain in seven centres shows an exceptionally low degree of infection, but the Øtofte strain of Wilhelmsburger appear to be still more resistant. The resistance of this strain was very forcibly brought out in the Sebonig centre in 1925,

where it showed no infection whatsoever, whereas the adjacent plots of Lord Derby showed 50 per cent. infection. This is also confirmed by reference to Table V. Bangholm Studsgaard appears to be more susceptible than the other two Danish strains (Table IV). These figures were obtained at lifting time, and no consideration was taken of the roots which may have rotted altogether earlier in the season. The frequency of blank spaces was much more noticeable in British than in Danish strains and if these gaps were due to rotting caused by " Finger and Toe " then the average infection figures for the British varieties should be considerably higher. In this respect Wilhelmsburger appeared to be very regular.

In 1926 it was considered advisable to carry out experiments to test the resistance of strains obtained from different sources of origin. The results are shown in Table V. There appears to be a very wide range in degree of resistance as between various commercial sources of seed of the same strains and a still greater difference as between pedigree and commercial strains. The resistance of Wilhelmsburger is again emphasised, and the figures for Studsgaard and Hernig agree with those in Table IV.

A chemical analysis of the different kinds is given in Table VI. These figures were kindly supplied by Mr. T. W. Fagan, M.A., Adviser in Agricultural Chemistry at Aberystwyth College. The average dry matter content of the Danish swedes is slightly higher than that of the British varieties. The composition of the dry matter does not reveal any significant difference as between the various sorts, but a slightly higher percentage of phosphoric acid is shown by Studsgaard and Wilhelmsburger.

Conclusion.

The superior resistance of the Danish strains to " Finger and Toe " is amply proved by these trials. None of them is altogether immune, but the degree of infection of some of the strains is very slight when compared with British varieties included in these trials. There is no doubt that the Danish varieties are capable of giving a substantially higher yield per acre on heavily infected land. They are considerably outyielded by some of the British varieties at any rate on healthy land but possess better keeping qualities. This is the experience of many farmers who have already grown them in this area during the past few seasons. Bearing this in mind it would be often advantageous to sow part of the swede crop with varieties of good keeping qualities even on healthy land, where roots are required to last until the end of the winter months.

An additional point in their favour is their comparative resistance to mildew, which has caused considerable damage to the swede crop in this area in the past. On the other hand, Wilhelmsburger seems to be the most susceptible strain to the attacks of the Swede Midge Fly.

It is important for farmers to realise that there are several strains of Danish Bangholm swedes, but only a few strains are reputed to be resistant to " Finger and Toe ", among them being the Hernig and Studsgaard strains, and also the Øtofte strain of the variety Wilhelmsburger. Again, not only is the strain important, but there is evidence to suggest that the source of seed is equally significant. Finally, on farms where " Finger and Toe " is troublesome and lime difficult to obtain, farmers would be well advised to consider the introduction of some of these resistant strains of swedes. At the same time liming would be an additional insurance against the ravages of the disease.

SOIL SURVEY OF WALES. PROGRESS REPORT, 1925-27.

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In a former number of this Journal (Vol. II, p. 142), some account was given of the proposals for the soil survey of Wales. During the past two years work has been proceeding steadily and a considerable body of data has been collected. We intend in the present paper to give an account of what has been achieved. We shall deal with three different areas, which will be considered separately. It will be helpful in the first place, however, to give some idea of our methods of working, as this will enable readers to understand the significance of the data which we have obtained and the generalisations which we have made from them.

In earlier survey work in North Wales, attention was directed principally to the collection and analysis of soil samples, and this is, of course, an important part of any soil survey because it gives a quantitative basis for the whole work. Up to the institution of the survey of Wales as a whole, however, no attempt had been made to construct systematic maps in the field. Such maps demand the organisation of continuous field work, which was not

possible until the necessary funds were available for appointing special assistants. The experience gained in the collection and analysis of soil samples from different parts of North Wales was, nevertheless, of considerable value and we were thus, at the outset, quite familiar with the principal types of soil of the area.

The soil survey as now carried out has two aspects, namely, the mapping and recording of data in the field, and the collection and analysis of soil samples. Soil analysis is useful because it gives information as to chemical composition which can only be obtained conjecturally in the field, and also serves to confirm and give precision to the judgment of the field worker as to soil texture.

In the first phase of the work we have attempted to record on our field maps all the most important data so far as they can be ascertained by inspection. Our base maps on which these data are recorded are the 6 inches to the mile series of the Ordnance Survey. Following a conference of British soil survey workers at Leeds in 1926, it was agreed that the following data should be collected and recorded by appropriate symbols :—

(1) *Surface.* Whether flat, undulating, sloping, irregular, etc., arrows being used to indicate direction of slopes.

(2) *Stoniness.* Different degrees are distinguished from stoneless soils to soils in which the rock is dominant at the surface.

(3) *Texture.* Indicating the principal texture classes from gravel to clay.

(4) *Colour.*

(5) *Water Conditions.* Distinguishing dry, satisfactory, and wet, and further subdividing wetness as to whether it is seasonal, due to springs, flooding, or the presence of a water table near the surface.

(6) *Profile.* Distinguishing soils according to their relation to the underlying strata, e.g., thin soil on rock, soil passing through subsoil to rock, soil on drift, alluvial soils, etc.

(7) *Notes on Vegetation and Cropping.*

In addition to the data recorded by means of symbols on the six-inch map, notes are made in the field note book on the general character of the soil profile at different points, together with any other circumstances of interest or importance.

It was thought at first that it might be possible to carry out the mapping field by field, and for intensively cultivated areas

such a detailed investigation might be demanded. Generally however, such detail would entail too slow a rate of progress and we now use a certain amount of grouping of fields where soil conditions appear to be similar. In certain cases, on the other hand, we have studied particular areas in very great detail, spending perhaps two or three days in the investigation of one field. Such a degree of detail would, generally, only be justified by the scientific value of the results obtained. It could only be of practical value where very intensive cultivation is contemplated.

From what has been said, it will be evident that in the actual work of the soil survey, the principal object is the collection of all relevant data as to the soil and the conditions under which it occurs. This information is, as far as possible, recorded on the six-inch maps. The remaining information is in the field notes and the analytical data obtained from the laboratory examination of the collected soil samples. It is obvious that the publication of all these data could scarcely be contemplated, on the grounds of expense, and they are to be regarded as in the nature of archives available for inspection. In order to make the information generally accessible, it is, therefore, necessary to generalise the collected data—in other words, to arrive at some system of soil classification. In dealing with the immense accumulation of data we are aware of an embarrassing choice of methods of classification. In fact, there is scarcely a circumstance connected with the soil which might not under certain conditions provide the basis of a system of soil classification. It is further to be noted that whatever system of classification be adopted it is always possible to carry it a stage further. Even in an apparently uniform field, we can distinguish differences in the soil which might be used in the making of a detailed map. We have, however, attempted in our classification to observe certain considerations which appear to us to be of first importance, namely, (1) to classify the soil of a locality in such a manner as shall best throw into prominence those differences which are of importance for plant growth; (2) to effect a compromise between excessive complication and excessive simplification by generalising our data so that they may readily be shown on the scale of one inch to the mile; (3) to treat each area as a problem in itself, postponing for the present the generalisation whereby all the soils of Wales shall be brought into one scheme of classification, but yet bearing in mind the necessity of relating our soils to a wide system of classification such as that used in the "Soil Map of Europe" recently published by the International Society of Soil Science.

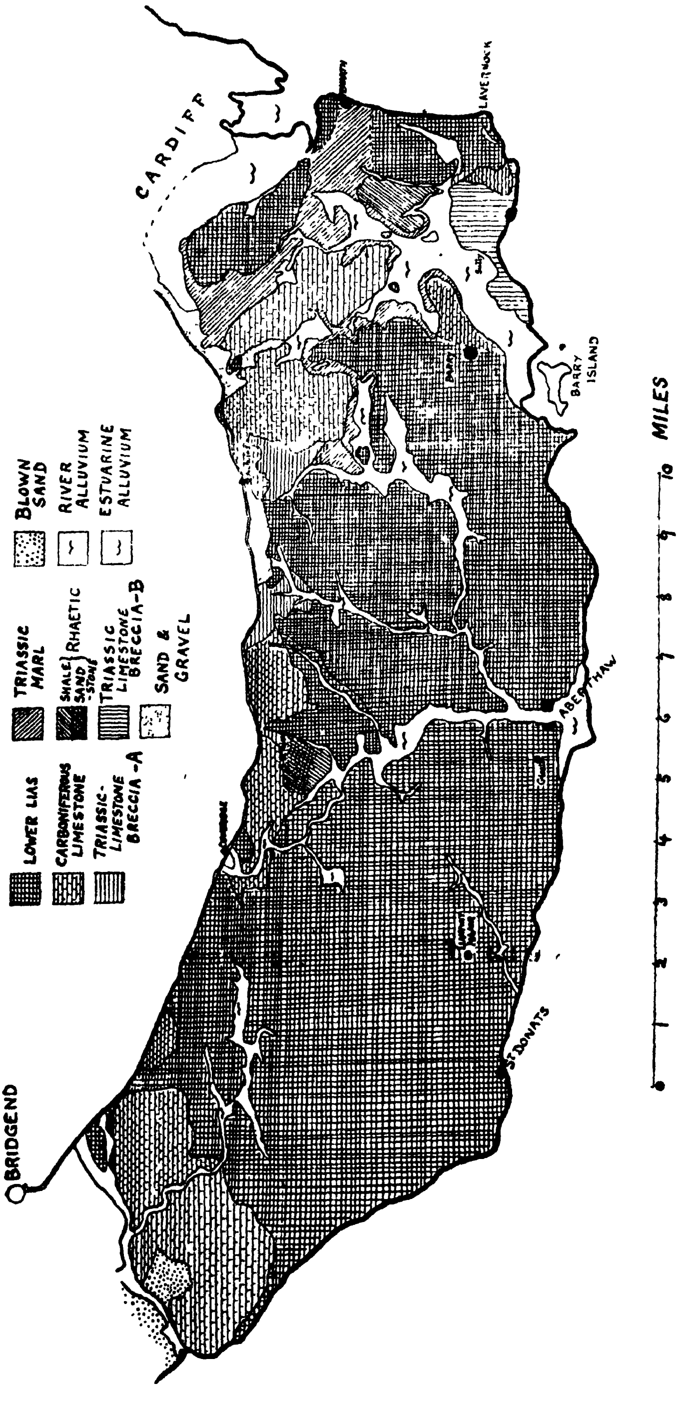


FIG. 1. Soils of S. Glamorgan.

Glamorgan and Monmouth.

The work in this area relates principally to that part of the Vale of Glamorgan lying to the south of the Cardiff and Bridgend road. Some preliminary reconnaissances have been made in Monmouth and a number of samples of soil have been collected, but no systematic mapping has been attempted in this county. The principal area in the Vale of Glamorgan has proved fairly convenient on account of the practical absence of glacial drift over most of the area surveyed, glacial deposits only coming in along the northern part of the area. The soils are thus mainly sedentary and alluvial. Generally speaking the Vale of Glamorgan is fairly level or gently rolling in character. The climate is of a maritime type with a mean annual rainfall of 40 inches or more, and no great extremes of heat and cold.

In attempting to generalise our data, we have naturally examined the practicability of using the geological character of the parent material as the basis of our classification. Our conclusion is that the soils of this area can be satisfactorily classified on a geological basis, and we have provisionally separated the following types.

Sedentary Soils.

1. Lower Lias Limestone soils.
2. Carboniferous Limestone soils.
3. Triassic Limestone Breccia soils.
4. Triassic Marl soils.
5. Rhaetic soils.
6. Old Red Sandstone soils.
7. Pennant Grit soils.

Alluvial Soils.

8. Estuarine Alluvial soils.
9. River Alluvial soils.

Glacial Soils.

10. Sands and gravels.

We give in Table I analytical figures for representative soils of each type. We have not included figures for citric soluble phosphate and potash, nor for available lime, because these vary so much from soil to soil that no individual figure can be taken as representative of the type in the same way that a mechanical analysis can be taken. It should be added that the mechanical analyses were carried out by the A.E.A. official (1926) method, based on work carried out at Bangor.

TABLE I.

Analyses of typical Soils of Glamorganshire.

	Lower Lias.	Rhaetic.	Carboniferous Limestone.	Triassic Limestone Breccia. A.	Triassic Limestone Breccia. B.	Triassic Marl.	Old Red Sandstone.	Pennant Grit.	Sands and Gravels.	Triassic Alluvium.	Lias Alluvium.
Coarse Sand	1.2	4.1	8.4	2.5	7.6	3.2	19.4	22.2	27.6	11.1	0.0
Fine Sand	8.8	7.8	18.2	19.4	32.8	16.5	27.8	24.9	24.4	27.0	.4
Silt	17.3	13.5	17.5	21.5	13.2	22.8	14.0	15.5	16.8	21.8	8.3
Fine Silt	26.5	20.0	15.0	11.5	14.0	17.5	16.0	11.2	6.8	13.2	18.3
Clay	31.5	31.0	22.5	27.8	20.8	25.8	15.0	14.2	11.8	16.3	42.3
Hygroscopic Moisture	5.0	5.9	3.6	4.5	2.2	3.9	2.5	3.0	2.6	3.2	8.6
Ignition Loss	9.7	13.5	12.0	10.4	5.8	9.9	5.3	9.2	8.7	8.5	19.0
Calcium Carbonate	2.5	4.2	0.0	1.5	0.0	0.0	0.0	0.6	0.0	0.0	0.0
Soluble in 20% H Cl. % K_2O	1.00	1.70	0.632	1.60	0.476	1.142	0.90	0.282	0.327	1.218	1.343
Soluble in 20% H Cl. P_2O_5	0.18	0.14	0.148	0.11	0.089	0.111	0.09	0.194	0.119	0.117	0.147

Lower Lias Soils. This formation occupies over half the area surveyed. The surface is generally fairly flat. The soil is remarkably uniform in texture and constitutes one of the best defined soil types encountered in the soil survey of Wales. The parent rock appears to weather down completely and the soil is practically stoneless. The profile is generally of one type, namely, six to nine inches of greyish brown surface soil and about the same depth of a much stiffer yellowish subsoil which passes at three feet or less to the bluish grey parent limestone. It is a very heavy soil under cultivation and requires careful handling if a good tilth is to be obtained. The satisfactory proportion of calcium carbonate doubtless mitigates considerably the clay character of these soils, and the area as a whole must be considered as fairly fertile.

One difficulty in connexion with these soils calls for mention. We refer to the trouble occasioned by anthills. Everywhere on the Lias these are abundant and, apart from their possible effect in depressing the productivity of grass land, are a serious obstacle when grass is brought under the plough. The pest would appear to be sufficiently serious to call for investigation with a view to devising counter measures.

Liming is, of course, unnecessary on these soils. We have noticed that the figures for available phosphoric are generally on the low side, indicating a possible tendency to deficiency in this manurial ingredient. We understand, however, that basic slag is not uniformly effective in promoting improvement. This may be due to a depression of the availability of the slag on these soils. The problem is certainly worthy of investigation.

Carboniferous Limestone Soils. We have found in South Wales, as in North Wales, that the soils associated with this formation show considerable variation, but may be divided into two types, namely, a lowland and an upland facies.

The typical profile in the lowland facies consists of 6-9″ of reddish brown medium stony loam over a more reddish subsoil of similar texture and stoniness. The rock is reached at two feet or less, depending largely on the contour. The soils of this facies are of fair average fertility.

The upland facies, occurring in the west of the area, is generally a thin soil on rock. On account of their dryness these soils are generally of low productiveness, being used mainly for rough sheep grazing. Gorse and bracken are often dominant. Another circumstance which contributes to their poor character is the fact that they generally occur in cold exposed situations.

The lime status of the Carboniferous Limestone soils appears to be generally satisfactory, and, although calcium carbonate may be absent owing to leaching, there is usually an adequate supply of lime in other forms.

Wind Blown Sands. Over a portion of the upland facies of the Carboniferous Limestone, a certain amount of wind-blown sand occurs, notably in the Ogmore district. It forms a poor, hungry soil, exposed to drought and carrying a poor type of sheep grazing.

Triassic Limestone Breccia Soils. These soils are derived from littoral beds of the Trias and we have distinguished two sub-types. (*a*) A heavy type occurring in the vicinity of St. Nicholas. These soils are derived from a rock known locally as bastard limestone. The usual profile is 6-9″ of yellowish brown heavy loam passing to a yellowish stiff clay subsoil. The profile is stony throughout owing to the resistance to weathering of the limestone constituent of the breccia. We have noticed that the grass herbage on these soils frequently shows a twisted appearance and a colour suggesting chlorosis. (*b*) A light type occurring in the Sully district. The red marl matrix gives these soils a reddish colour. They are light to medium loams. The depth varies and in some places the rock occurs at a few inches from the surface. The deeper soils are fairly fertile.

The soils of the limestone breccias are generally satisfactory as regards their lime status, but may be deficient in available phosphate.

Triassic Marl Soils. These form a very uniform type. The weathering is deep and the profile is generally 9-12″ of reddish medium loam, passing almost imperceptibly into subsoil of similar character but rather brighter in colour. Fertility is generally good. There are also, associated with the Red Marls, Green Marls which give rise to a rather heavier type of soil, which we should regard as being less fertile than the Red Marl soils. They have a greyish colour. The Triassic Marls are generally adequately supplied with lime.

Rhaetic. Two types are obtained from this formation. The more extensive is derived from the shales and is a heavy loam or clay, often of a cold, wet character. In the main it is rather similar to the Lias type, and as it commonly occurs as narrow strips surrounding the latter, Rhaetic soils may generally be considered with the Lias. The main distinction between the two types of soil is probably in the less complete weathering of the Rhaetic, which is appreciably stony. The normal profile is a

brown heavy loam, changing at about 6″ to shallow yellowish impervious clay.

The second type, derived from a sandstone, also occurs to a limited extent. The profile is generally about 9″ of sandy loam over a yellowish subsoil of similar texture.

Old Red Sandstone Soils. Although there is no appreciable extent of these soils in the area mapped by us, we have examined a few samples from Monmouthshire, and it may be of interest to give a short description of their chief characters. The soils examined were mainly derived from the Marls and were red medium loams. One feature of these soils is the high proportion of the middle fractions, fine sand and silt, found in mechanical analysis. They are generally fertile soils with a satisfactory lime status. We have not sufficient experience to generalise as to their phosphate status.

Pennant Grit Soils. These do not occur in the area mapped, but a large number of Pennant Grit soils have been examined in the course of advisory work. They are light loams and appear to be rather below the average in fertility, although it must be remembered that they occur in less favourable situations than the other soils described. Deficiency in lime is possible in this series, although a fair proportion of the samples examined were not in immediate need of liming. Available phosphate appears to be on the low side.

Marine Alluvium. Much of the marine alluvium of our area is in an unimproved state or else occurs in urban areas. We have not, therefore, devoted much attention to it, but shall study it more carefully when we come to the mapping of the adjacent parts of Monmouthshire, where it is of considerable importance. In this area it forms a heavy clay soil which could only be utilised for grazing.

River Alluvium. The character of the alluvial soils in the river valleys of our area varies considerably according to the formation from which the alluvium has been derived. We can, for instance, recognise certain alluvial soils which are derived from Lias material, others from the Triassic Marls. The Liassic alluvium is extremely heavy and impermeable. Waterlogged areas are common and even the drier portions are infested with rushes and afford a coarse type of grazing. The Triassic Marl alluvial soils, on the other hand, are better drained and carry particularly good pastures.

Glacial Sands and Gravels. In the area now under discussion glacial drifts only occur along the northern margin. The soil

type associated with the glacial sands and gravels is rather variable, ranging from gravelly soils to sandy loams. No great extremes were found in the small area mapped. These soils appear to be fairly satisfactory and show no marked deficiencies.

Eastern Anglesey.

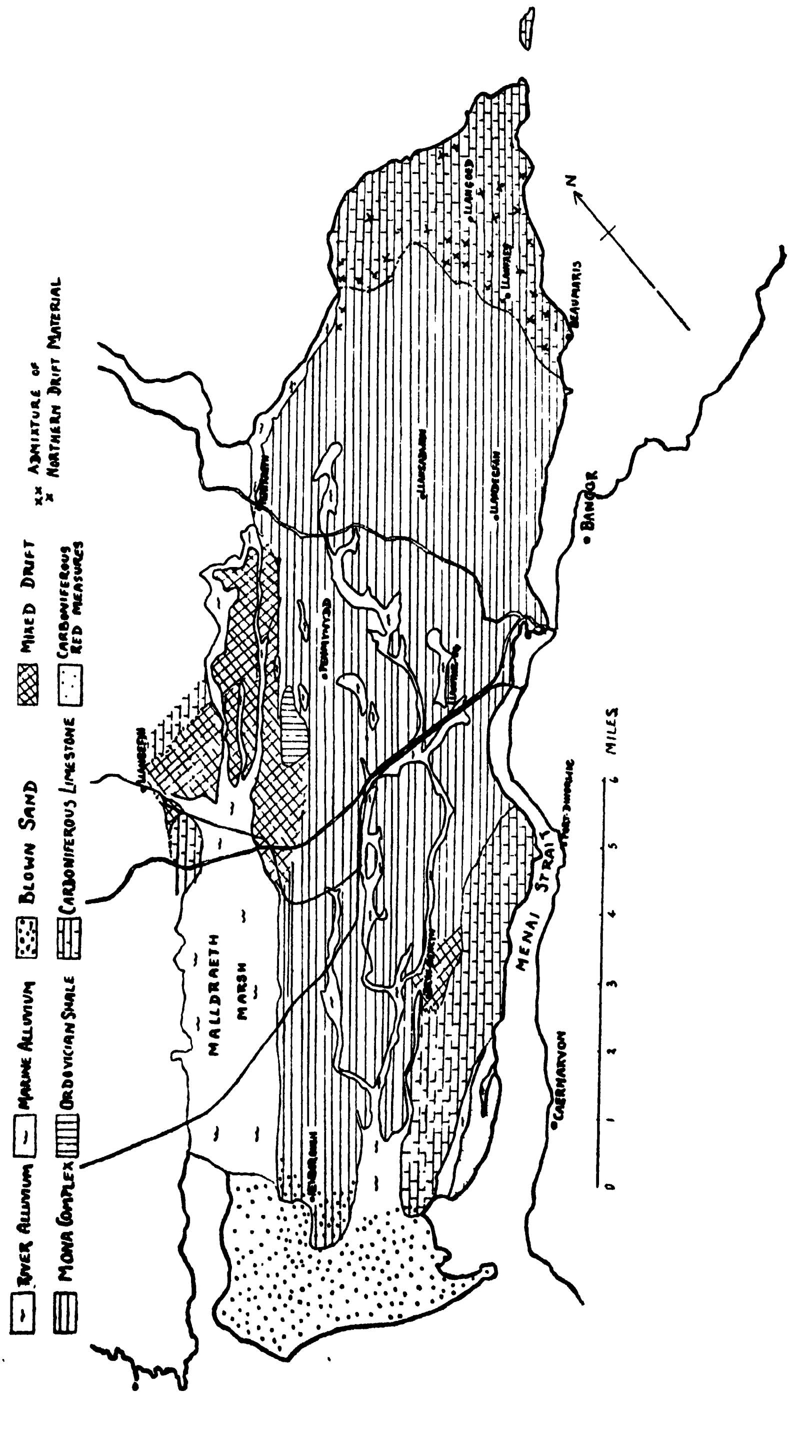
The area in question is that part of Anglesey lying to the east of the Malltraeth-Pentraeth Valley. It is generally a lowland area and in its southern portion forms a series of ridges and valleys running in the same NE-SW direction as the Malltraeth-Pentraeth valley. In the north the topography is more complex and includes the hills of Mynydd Llwydiarth and the Carboniferous Limestone uplands of the Penmon area.

The climate is definitely maritime, with cool summers and mild winters. From the meteorological statistics collected month by month by the Ministry of Agriculture it would appear that this area is almost as warm in winter as Cornwall, for the temperature readings at Aber, on the Caernarvonshire side of the Menai Straits, are very similar to those for Gulval, Penzance. It is doubtful if the possibilities conferred by this mild winter climate are fully realised. The average annual rainfall varies from less than 30 inches in the extreme north and south to nearly 40 inches in the central portion.

Geologically the area is rather complex, but the rocks may for convenience be grouped into three categories. These are, in order of importance, (1) the metamorphic rocks of the Mona Complex, principally Gwna Green Schists, and Penmynydd Mica Schists; (2) The Carboniferous rocks, including the Carboniferous Limestone, Carboniferous Sandstone, Millstone Grit, and Red Measures; and (3) Ordovician Sedimentary rocks, including shales and sandstones. The geology is, however, greatly complicated by the fact that only a small portion of the area is free from glacial drifts. The drifts of the area are the result of the activities of the Irish Sea glacier and are generally fairly closely related to the local rocks. For example, in the Mona Complex area, the drifts are generally formed of the débris of metamorphic rocks, except that in the north-east material from the adjacent rock formations tends to invade the Mona Complex area. There is also in the north a certain extent of red boulder clay, probably consisting of Triassic material. The geological formations, though generally drift covered, are thus of importance as furnishing the parent material for the soils of the area.

The central part of the area is complicated through being greatly dissected by streams in whose valleys are alluvial,

FIG. 2. Soils of East Anglesey.



colluvial, and lacustrine deposits. These deposits are, however, closely related, so far as their composition is concerned, to the local glacial drifts, out of which they have been formed.

It will be easily seen that the classification of the soils of this area on the basis of the geology is likely to be a task of some complexity. We are aware, from earlier work in Anglesey, that so far as actual composition is concerned there is little difference between soils derived from the different rocks of the Mona Complex, and that there is no great difference in composition between the sedentary soil derived from a given rock and a soil derived from the same rock material occurring in the form of drift. We propose, therefore, to separate out as a series the soils mainly derived from Mona Complex material, whether sedentary or drift soils. We feel justified in referring to these as the Mona Complex series because from the soil formation standpoint the different constituents of the Complex appear to be very similar. We should, of course, except from this generalisation quartzites and other very acid rocks, which, however, do not occur in the area we are discussing. We may similarly distinguish a Carboniferous Limestone series. We are aware that the Carboniferous Limestone includes rocks of very varying character, but we cannot at present arrive at any satisfactory subdivision of the series, except by considering situation and other circumstances. We shall provisionally separate the soils associated with the Red Measures of the south of our area, since these appear to be distinct from other Carboniferous soils in their general character. In the same way we distinguish an Ordovician series of soils. It is not of wide extent in our area, but becomes of considerable importance in central Anglesey. The Ordovician rocks of the Beaumaris area are covered with deep drift and appear to have little importance from the point of view of the soils of the district. We have also separated out the alluvial soils and the wind-blown sands.

Our first classification in Eastern Anglesey is thus based on the geology, but inasmuch as we are only using the geology as indicating the nature of the parent material it involves considerable simplification. For the further subdivision of our soils we have the choice of a number of methods. We could, for example, sub-divide each series into sedentary and glacial drift, or we could classify according to texture. We have also in this area been impressed by the value of a classification based on water conditions. This is particularly the case over a large portion of our area, where the soils all belong to the Mona Complex series and show comparatively slight variations in texture. In generalising

our data, therefore, we have prepared three maps on the scale of one inch to the mile. The first map, which we reproduce in the present paper, shows the distribution of the different series, Mona Complex soils, Carboniferous soils, Ordovician soils, Alluvial soils, and Wind-Blown sands. The second shows the texture differences, and the third shows the water conditions. The second and third maps cannot be shown here through lack of space.

For the purpose of the present paper we shall describe the soils according to the series which we have separated out in our first classification. Analytical figures are given in Table II.

Mona Complex Soils. As stated above, these soils are derived from the metamorphic rocks or débris of the Mona Complex. They may be regarded as soils in the earlier stages of mechanical disintegration. Mature profiles in which the characteristic soil horizons are developed scarcely occur. Texturally they are generally light or medium loams containing a fair proportion of stones. They are, except where the drainage is bad, generally of a brownish red colour. The reddish colour is most evident in the small area of soils derived from the glaucophane and hornblende schists. The sedentary soils and the soils derived from sands and gravels are generally well drained and even in some cases liable to suffer from drought. The lower lying boulder clays are frequently wet and show the greyish colour which indicates deficient aeration. The alluvial and lacustrine soils associated with this series are very variable, but are rarely heavy in texture. Agriculturally these soils are of fair fertility and, except for the valley bottoms, are ideal arable soils which would appear to be well suited for intensive market garden cultivation. Scattered throughout the area are thin rocky soils occupied by a heath vegetation. These patches are generally of small extent, but on Mynydd Llwydiarth there is a considerable area of upland heath which appears to offer small prospects of profitable utilisation, unless it might be afforested.

From our analytical data it would seem that the only marked natural deficiency in these soils is lime. They appear to be reasonably well furnished with the other elements of plant nutrition, although intelligent manuring is necessary for successful farming. With regard to liming, we find that, although the Mona Complex soils do not contain free calcium carbonate, there is generally an adequate amount of lime for immediate needs in the form of easily available lime compounds associated with the clay and organic matter. It is likely, however, that the present satisfactory condition of the ordinary soils of this series

TABLE II.

Analyses of typical Soils of East Anglesey.

	Gwina Green Schists.	*Carboniferous Limestone.*	*Ordorician Shales.*	*Red Measures.*	*Northern Boulder Clay.*	*Blown Sand (Newborough).*
Coarse Sand	17.7	15.1	12.5	24.4	13.8	51.6
Fine Sand	24.5	26.6	18.3	23.1	19.4	25.3
Silt	12.3	13.3	14.2	11.9	11.0	4.1
Fine Silt	14.6	15.0	15.2	13.5	15.9	5.8
Clay	17.6	16.4	17.7	15.1	25.3	6.0
Hygroscopic Moisture	4.1	2.4	4.2	1.9	2.3	1.3
Ignition Loss	9.7	10.2	16.7	7.8	10.2	4.9
Calcium Carbonate	0.0	0.74	0.0	0.0	0.0	0.0
Soluble in 20% H Cl. % K_2O	0.483	0.420	0.616	0.645	1.130	0.197
Soluble in 20% H Cl. % P_2O_5	0.213	0.165	0.270	0.142	0.050	0.084

is due to the large applications of lime or other calcareous materials in the past, and that the rapid leaching out of lime consequent on the wet climate will in time lead to an actual depression of fertility owing to lime deficiency. It is likely that this deficiency will manifest itself first in the well drained upland soils. We cannot too earnestly recommend farmers to give attention to this point. Liming being rather an expensive operation, it should never be undertaken without seeking advice. This advice is obtainable gratis at Bangor. Whilst it is often difficult to say certainly whether a particular soil will respond to liming, it is generally possible to inform the farmer as to cases where liming is likely to be unprofitable. We have in some cases, though not in Anglesey, found liming carried out on fields which were already well supplied with this constituent. In such cases an enquiry addressed to the College might have led to a considerable saving.

Carboniferous Limestone Series. Carboniferous Limestone occurs in two areas in Eastern Anglesey, namely, the Brynsiencyn district opposite Caernarvon, and the Penmon district in the north-east of the area There is comparatively little sedentary soil in the southern portion, but in the north-eastern portion in the Penmon district, thin sedentary soils are found in the uplands. These are generally uncultivated and covered with a heath vegetation or else with short grass. The lowland type, which is formed from glacial drift, is generally a fertile light loam of a brown or, in some cases, red colour. We have found the Carboniferous limestone soils somewhat difficult to classify, owing to the great variations which occur among them. It is true that they are generally light or medium loams, but there are great variations in their lime status, some soils containing fair amounts of calcium carbonate whilst others are even deficient in lime. In the northern portion we conclude that there is a considerable admixture of northern drift, probably of Triassic origin. There are actually extensive sheets of heavy red boulder clay in many parts of the north Welsh coast. This clay occurs at Llangoed in our area. In a few localities it actually appears to give rise to a soil which of course could not be considered as belonging to the Carboniferous series. With regard to these soils, then, the map given must only be regarded as a broad generalisation.

Red Measures. In the part of Anglesey opposite the town of Caernarvon there is a small area of Red Measures. The soil associated with these rocks is a light loam of a reddish colour. It is probably much mixed with limestone drift and cannot be

considered a well-defined type. On it is found some exceedingly good grazing land. Red soils are also found on the Caernarvonshire side of the Straits.

Ordovician Series. The soils derived from Ordovician sedimentary rocks do not occupy any large portion of our area. As was mentioned above, the Ordovician rocks of the Beaumaris district do not appear to have any effect on the soil of the district. In the Penmynydd district, however, soils derived from Ordovician rocks occur. The parent rock here is fissile shale and the derived soil is typical of the lighter soils of that class which has been described as the Palaeozoic Silt Loam. It is a greyish brown medium loam, containing a fairly large proportion of stones. We should regard the Ordovician soils in this area as being rather less fertile than the soils of the Mona Complex. The series occupies such a small extent in the area which we are considering that we shall postpone a full discussion until we have to deal with the other part of Anglesey, in which Ordovician soils are of considerable importance.

Blown Sands. Along the south coast of Anglesey there are considerable stretches of dune sand. Such a stretch occurs in our area at Newborough Warren. On the landward side some of this soil is under cultivation, being used mainly for market garden culture. It is an exceedingly light sand and could not be used for the growth of crops at all but for the fact that the water table is fairly close to the surface. Blown sand is found mixed with the soils of the Mona Complex series for a mile or two inland.

Marine Alluvium. The principal area of Marine Alluvium is Malltraeth, a stretch of land reclaimed by means of an embankment over a century ago. The drainage at present leaves much to be desired, for large stretches are flooded in wet weather. The soil is generally of a sandy or sandy loam character. The climate, as has been mentioned above, is not unlike that of Cornwall and we may venture the opinion that if the drainage were satisfactory the whole of this area might be under intensive market garden cultivation. Considering the extent of the area, about 8,000 acres, and the fact that the most serious part of the drainage work has already been carried out, it would seem that a moderate expenditure on completing the improvement might prove of great profit. An area such as this in Holland would certainly be intensively utilised.

East Denbighshire.

The area under discussion forms an irregular shaped extent of country, with Wrexham as its centre. In the east it is a featureless lowland, whilst in the west it passes into open

mountain. The region immediately round Wrexham is undulating, the principal features being due to glacial gravel ridges. The area was chosen in order to arrive at a practical method of classifying soils in an area of glacial drift and alluvium.

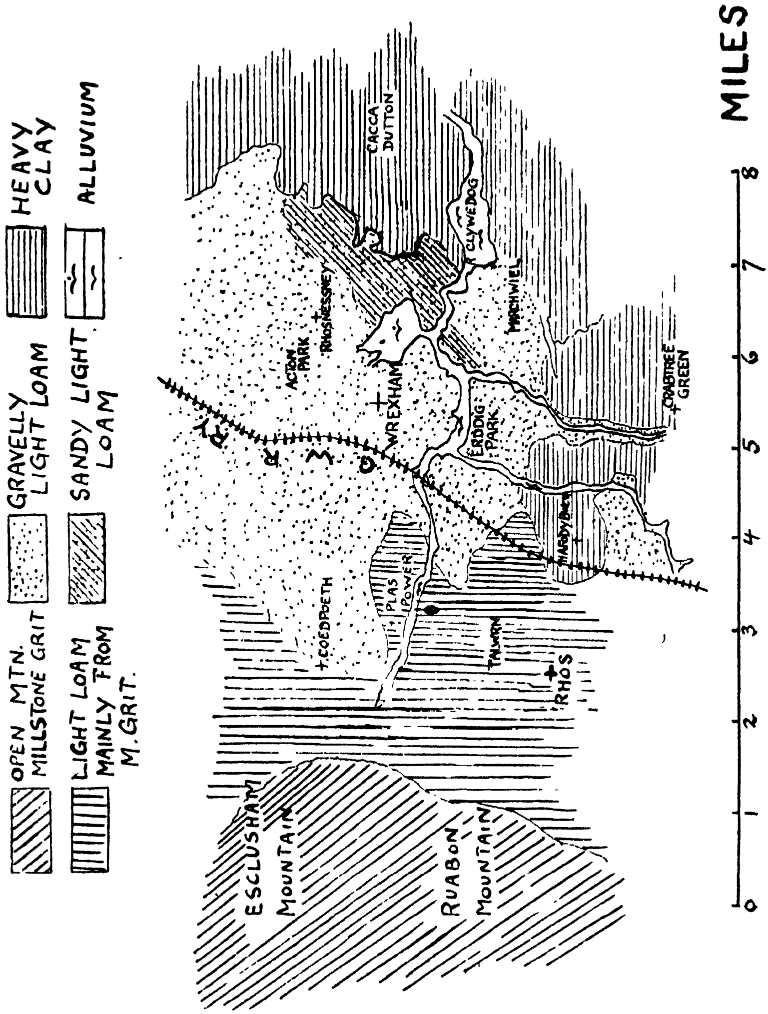


FIG. 3. Soils of Wrexham District.

The climate is less maritime in character than in the other areas. The mean annual rainfall is about 32-34 inches, increasing to the west and decreasing to the east. The mean January temperature is probably about 38-39° and the mean July temperature about 60-61°. The drift would appear to be largely of Triassic origin around Wrexham and to the east, but there is doubtless a certain contribution from Carboniferous rocks of the Coal Measures and Millstone Grit. West of Wrexham the drift

becomes increasingly of Millstone Grit material. Recognising the complexity of the drifts of this area, it has appeared to us that, for the present, the most useful way of classifying the soils of the Wrexham district is on the basis of their texture. There is a considerable range in this respect, and although one textural type often shades insensibly into the other, the differences are sufficiently marked to afford a basis for mapping. We have distinguished the following types, for which analytical data from typical soils are given in Table III.

1. Mountain soil mainly sedentary on Millstone Grit.
2. Light loam mainly derived from Millstone Grit material.
3. Gravelly light loam.
4. Sandy light loam.
5. Heavy clay.
6. Alluvium.

TABLE III.

Analyses of typical Soils of Wrexham district.

	Nant Coedpoeth. Light Loam —Millstone Grit.	*Cacca Dutton. Heavy Clay.*	*Borras Head. Gravelly Light Loam.*	*Croes Foel. Sandy Light Loam.*
Coarse Sand ...	12·8	11·1	50·3	21·2
Fine Sand ...	21·8	14·4	12·6	21·7
Silt ...	20·1	14·8	8·8	14·8
Fine Silt ...	12·5	23·7	9·4	18·8
Clay ...	16·9	23·4	7·9	18·0
Hygroscopic Moisture	7·9	2·6	1·6	2·5
Ignition Loss ...	6·6	9·5	6·6	9·3
Calcium Carbonate ...	0·0	0·0	0·0	0·0
Soluble in 20% HCl.				
K_2O ...	0·449	0·826	0·340	0·446
P_2O_5 ...	0·088	0·115	0·170	0·128

1. *Mountain Soils.* These soils, which have not been mapped in any detail, generally carry a variable depth of peat. The vegetation consists mainly of coarse grasses with ling, bracken, or gorse. The profile is typically about 4″ of peat over 4″ of greyish light loam passing to a rubbly yellowish brown subsoil over the parent rock.

2. *Light Loams.* This type occupies a considerable area between the open mountain and the lowland. The typical profile shows 9-12″ of stony light brown loam passing into a yellowish, slightly stony subsoil, which on the ridges is often somewhat indurated. On the higher ground it appears to be liable to

seasonal drought, but is generally of fair fertility. The parent material is glacial drift, probably of Millstone Grit origin.

3. *Gravelly Light Loam.* This type occupies the central portion of the area. The parent material is well seen in the railway cuttings on the G.W. Railway line between Chester and Wrexham, and is a glacial gravel, probably of Triassic origin. The soil is a brown gravelly loam passing at 9-12″ to a lighter brown or reddish gravelly subsoil. On banks it may suffer from drought, whilst along the valley of the Alyn there are frequently rushy and peaty stretches owing to springs. With satisfactory rainfall these soils are fairly fertile under mixed husbandry.

4. *Sandy Light Loam.* This type is probably a heavier phase of the preceding type. The profile shows a reddish brown sandy loam of good depth over a yellowish or reddish sandy subsoil.

5. *Heavy Clay.* This type forms the featureless plain to the east of our area. The soil is a heavy stoneless clay and little change in texture is observed in the profile. Its impervious character renders it liable to waterlogging and it is generally under grass of fair quality.

6. *Alluvium.* These are heavy soils under grass.

Conclusion.

In the present article we have attempted to present the salient characters of the soils of the three areas which have been mapped. We would, in conclusion, remind our readers that the classification of soils into types is merely a device for the presentation of collected data, and that a map showing soils separated into types cannot convey all the information collected about them and must therefore be interpreted with critical judgment.

We have attempted to classify our soils in such a way as to show with the greatest contrast their important properties from the standpoint of agriculture. We realize, however, that in the purely scientific study of the soils of Wales other methods of classification must be used. We are naturally desirous of relating our soils to the soils of Europe, for which a provisional classification has already been devised. In this classification the soils of Wales would appear to belong to those types produced by intense leaching in cool climates, of which the podsol soils are the example. In the investigation of soils for the purpose of scientific classification it is necessary to study soils in which the natural mature profile has been unaltered by cultivation or other agencies. We must, therefore, postpone intensive study of the natural relationship of our soils until we have accumulated more data from the uncultivated areas.

CARBOLINEUM SPRAY TRIALS IN WALES.

In accordance with resolutions adopted by the Welsh Agricultural Education Conference at its meeting at Cardiff in December, 1926, a number of trials of Carbolineum Winter Washes were carried out in Wales during the winter of 1926-27. The orchards sprayed under the scheme were subsequently examined by the Advisory Entomologist for the area concerned, the report of the three advisors being given below.

Trials in North Wales.

Examination and report by C. L. Walton, M.Sc., Ph.D., in consultation with the County Horticultural Officers, the examinations being made during May and June, 1927. What follows is a summary of the report submitted by Dr. Walton.

ANGLESEY.

Four orchards were sprayed under the scheme, the sprayed trees being almost entirely apples. One orchard was not examined owing to lack of time, but the results are stated to have been excellent. In the three orchards examined the value of the treatment was clearly demonstrated. All sprayed trees were clean with the exception of a few small colonies of aphides in one orchard probably due to outlying twigs being missed by the spray. One lot of plums used as a control was severely attacked by aphides. Carbokrimp was used in each case.

CAERNARVON.

Spraying was carried out in eight orchards, the sprays used being Carbokrimp and Mortegg. Control of apple aphides was excellent, the sprayed trees being with very few exceptions entirely clean, whilst the controls were all infested in varying degrees. *Psylla mali*, the Apple Sucker, was also successfully controlled, the unsprayed trees being badly infested, particularly in the Chwilog district. Winter Moths were not completely controlled, but the damage was never more than slight. Where plums were sprayed control of the leaf curling aphis was excellent, sprayed trees being clean, and unsprayed heavily attacked. In general the sprays had a most beneficial cleaning action and the appearance of the foliage on sprayed trees was excellent.

As regards small fruit, the beneficial effect of the sprays was most marked, all sprayed black currants and gooseberries were clean, while in each case the unsprayed bushes were severely

attacked by aphides. This was particularly noticeable in the Madryn Farm orchard.

DENBIGHSHIRE.

Spraying was carried out in seven orchards, the sprays used being Carbokrimp and Mortegg.

In some of the trials, especially in the Ruthin district, the value of the sprays was not so clearly demonstrated owing to the unsprayed trees being very lightly infested, while in some cases sprayed trees showed light aphis infection. Control of the Black Cherry Aphis was clearly demonstrated at Ruthin, where the sprayed trees were clean and the unsprayed heavily infested. In the majority of the orchards, however, notwithstanding the slight degree of infestation, the value of the sprays in controlling the aphis pests of apples, plums, gooseberries, and black currants was evident.

FLINTSHIRE.

Five orchards were sprayed under the scheme, the sprays used being Carbokrimp, Mortegg, and Carbo. A particularly interesting experiment was that carried out on a Sealand small holding by the County Horticultural Superintendent. Boskoop Giant Black Currants were sprayed with Mortegg and with Carbokrimp at strengths of 10%, 7½%, 5%, and 2½% concentrations. All gave equally good control of aphides, the sprayed bushes being all clean while the unsprayed were all infested in varying degrees. It seems desirable that the effect of these lower concentrations should be tested further. In the case of the sprayed apples, all trees were clean with the exception of slight Winter Moth attacks and Woolly Aphis, and small aphis colonies on one Bramley's Seedling. The unsprayed trees were attacked by Aphides, Psylla, and Winter Moths in varying degrees. Control of the Gooseberry Aphides was also demonstrated.

Summary.

The trees and bushes sprayed in North Wales under the scheme numbered 2,065, and included apples, 1,452; pears, 34; plums, 44; cherries, 2; black currants, 368; and gooseberries, 165. The number of controls was not enumerated. The results were on the whole very satisfactory, no real failures to control having occurred. The few instances of the presence of aphides on sprayed trees were probably due to outlying twigs being missed. In all cases cleaning was good and the appearance of the sprayed foliage excellent. All sprays used gave equally good results.

Trials in Mid and West Wales.

Spraying carried out by the County Horticultural Instructors. Examination and report by J. R. W. Jenkins, M.Sc., in consultation with the County Horticultural Officers.

CARDIGANSHIRE.

Pentreshon, Lampeter.

Elevation 500 ft., slight South-West slope and exposed to North and East. Sprays applied on 21/2/27. Examinations carried out on 25/4/27 and 9/6/27.

The following bush apple trees were sprayed with Carbokrimp:—Rival (10), Worcester Permain (9), Allington Pippin (5), and Early Victoria (5). On none of the trees were any aphides found, caterpillar damage chiefly due to Winter Moth larvae occurred on 2-5% of the leading shoots, and an occasional *P. mali* was noted. As regards possible varietal differences, Rival and Worcester Permain were slightly more severely damaged by caterpillars, but the difference was probably not significant. A trace of Tortrix damage occurred on most trees.

Nineteen trees were sprayed with Mortegg, namely, Newton Wonder (10), Lane's Prince Albert (5), and Bramley's Seedling (4).

Two small colonies of *Anuraphis roseus* were found on the Newton Wonders, the trees being otherwise free from aphides. Winter Moth damage was least on the Newton Wonders, which were practically free, and greatest on the Lane's Prince Albert, where from 5-10% of the shoots were damaged. As regards the Bramley's, one bush had about 5% of its shoots damaged, while the others were practically undamaged. *P. mali* was scarce.

Fifty trees were allowed to remain unsprayed as a control, namely, Gladstone (10), Allington Pippin (10), Newtown Wonder (5), Early Victoria (5), Lane's Prince Albert (10), and Bramley's Seedling (10).

All the trees carried colonies of *Anuraphis roseus*, some of the infestations being remarkably heavy. Variety Gladstone was noticeably the most badly attacked, only three bushes had less than 10% of the shoots attacked and most of the remainder carried large colonies on practically every shoot. A few colonies of *Rhopalosiphum prunifoliae* were also noted. With the exception of Lane's Prince Albert, all the other varieties were approximately equal as regards aphid infestation, from 20-50% of the shoots carrying colonies. Lane's was less heavily attacked, the extent varying from a trace to 10% infested shoots. A few colonies of *R. prunifoliae* were also found on the Bramley's, otherwise *A. roseus* was responsible.

As regards caterpillar damage, this was almost entirely due to Winter Moth larvae, slight Tortrix damage being also present on most of the bushes. Lane's Prince Albert was noticeably the most heavily attacked, all ten bushes having from 50-75% of their shoots badly defoliated. Allingtons were also badly attacked, two bushes having almost every shoot damaged, with the remaining eight varying from 20% damage to slight. On the remaining varieties the average number of shoots damaged was about 25%. *P. mali* was present in very small numbers on most trees.

General Inference.

The trials gave an excellent demonstration of the value of sprays in controlling Aphides, only two small colonies being found on the sprayed bushes, whereas the unsprayed all bore colonies, very heavy infestations occurring with some varieties. Both sprays appeared to give equally good results. The degree of *P. mali* attack was too light to enable any conclusions to be made. The insects were to be found on most trees, but appeared to be rather more numerous on those left unsprayed.

A greater control over Winter Moth attack was obtained than is apparently usual. This is illustrated best by Lane's Prince Albert, the most heavily attacked in both sprayed and unsprayed bushes, but whilst the sprayed suffered from a trace to 5% damaged shoots the unsprayed had 50-75% attacked shoots. Similar results also occurred with the other varieties which figures in both sprayed and unsprayed portions.

The foliage of the sprayed trees was much more healthy looking than that of the unsprayed, and the bark was free from the incipient growth of moss and lichen found on the unsprayed trees.

Noyadd Wilym, Cardigan.

Elevation 200 ft., slight Southern slope and protected from North and East by mixed woods. Sprays applied on 28/2/27. Examinations carried out on 26/4/27 and 10/6/27.

Twenty-four bush apples were sprayed with Mortegg, namely, Bramley's Seedling (8), Early Victoria (8), Lane's Prince Albert (8).

Apple aphides were absent from all trees; an outstanding feature was a heavy Winter Moth attack on Lane's Prince Albert, where from 50-75% of the shoots were badly damaged, damage on the other varieties varying from 15-30% attacked shoots. *P. mali* was present in small numbers on most trees, as were Tortrix larvae. Traces of *Eriosoma lanigera* occurred on the Bramley's Seedlings.

Sixteen trees were sprayed with Carbokrimp, namely, Allington Pippin (8), Beauty of Bath (8). Apple Aphides were again absent, and a few *P. mali* noted on the Allington Pippins only. Small colonies of *E. lanigera* were also present on this variety. 35% of the Allington shoots and 10% of the Beauty of Bath shoots were attacked by Winter Moth larvae, and all trees harboured a few Tortrix larvae.

The following twenty-four trees were allowed to remain unsprayed as a control: Worcester Permain (8), Charles Ross (8), Newton Wonder (8).

A few odd shoots of Newton Wonder carried small colonies of *Anuraphis roseus*, the remaining trees being free from aphides. *P. mali* was present in small numbers on all trees. Newton Wonder was also the most severely damaged by Winter Moth larvae, an average of 30% of the shoots being attacked, with one tree practically defoliated. 5% of Charles Ross shoots, and 10% of Worcester Permain were attacked. Slight Tortrix damage occurred on most trees.

General Inference.

The value of the sprays in controlling aphis attack was not well illustrated, as although no aphides were found on the sprayed bushes only a few small colonies were found on the unsprayed. The degree of *P. mali* and Tortrix attack was so slight that conclusions are not justifiable. The control of Winter Moth damage secured at Pentreshon was not obtained here, as although unsprayed Newton Wonder was badly attacked, sprayed Lane's Prince Albert was attacked even more heavily. Since both sprayed and unsprayed Lane's Prince Albert were also the most heavily attacked variety at Pentreshon however, it is possible that varietal susceptibility to attack may enter into the question, and since at Noyadd Wilym no one variety was included in both sprayed and unsprayed portions, no unqualified conclusion as to the effect of the sprays on Winter Moth attack can be arrived at.

The sprayed trees were again more healthy looking and freer from parasitic plant growth than were the unsprayed.

Troed y foel, Aberystwyth.

Elevation 450 ft., slight North-West slope and very exposed. Spraying carried out 25/2/27. Examinations made on 22/4/27 and 11/6/27.

The following bush apples were sprayed with Mortegg:— Crimson Bramley (2), Delicious (2), Bramley's Seedling (2), Grenadier (3), Royal Jubilee (2), Lord Derby (1), Lord

Grosvenor (2), Lord Suffield (1), Cox's Orange (2), Lane's Prince Albert (1), and Newton Wonder (1).

Apple aphides were absent, and apart from slight Winter Moth damage to Lord Suffield and one Delicious, and a trace of Tortrix attack on one of the Bramley's Seedlings, the bushes were clean.

Thirteen bushes were sprayed with Carbokrimp, namely, Worcester Permain (5), Allington Pippin (1), Cox's Orange Pippin (1), Beauty of Bath (2), Charles Ross (1), Lane's Prince Albert (1), Bismarck (1), and Newton Wonder (1). Four plum trees and two pears were also sprayed.

The only damage was very slight Tortrix attack on Cox's Orange. Apple Aphides were absent.

Thirty-four bushes were allowed to remain unsprayed as a control, namely, Newton Wonder (4), Delicious (1), Worcester Permain (2), Cox's Orange Pippin (11), Annie Elizabeth (1), Mere de Menage (1), Bismarck (2), King's Acre Bountiful (2), Rival (1), Lane's Prince Albert (5), Dumlow's Seedling (2), and James Grieve (2). Nine pear trees were also unsprayed.

About half the apple bushes showed traces of Winter Moth damage, Lane's Prince Albert again being the most heavily attacked, about 10% of the shoots showing damage. Apple Aphides were scarce, a few small colonies of *Anuraphis roseus* were found on one of the Newton Wonders, and about 5% of the shoots of one of the Cox's Orange carried moderately large colonies. As regards the pears, the two Fertility trees were about 20% defoliated by Winter Moth caterpillars, this being the worst damage in the orchard. The neighbouring pears, Conference and Durondeau, were untouched.

General Inference.

Although aphis infestation of the unsprayed bushes was remarkably light, none were found on the sprayed bushes, and the value of the sprays was demonstrated. Similarly although Winter Moth damage on the unsprayed bushes was slight it was very definitely greater than that on the sprayed portion. The greater cleanliness and healthier appearance of the sprayed bushes was again apparent. *Psylla mali*, the Apple Sucker, was practically absent in the orchard, so the effect of the spray as a control cannot be judged.

BRECON AND RADNOR.

Tan-y-graig, Builth.

Elevation 700 ft. Slight Southerly slope and well sheltered. Spraying carried out on 10/2/27. Examinations made on 29/4/27 and 15/6/27.

The following twenty bushes were sprayed with Carbokrimp :—Annie Elizabeth (2), Lane's Prince Albert (2), Newton Wonder (2), Bramley's Seedling (2), Charles Ross (6), and Early Victoria (6). All the bushes suffered from very slight Winter Moth damage, with occasional Tortrix larvae here and there. Two of the Early Victorias harboured a few small colonies of *Anuraphis roseus*, and slight Thrip damage was noted on Lane's Prince Albert. No *P. mali* were observed.

Twenty bushes were sprayed with Mortegg, namely, Newton Wonder (3), Allington Pippin (3), Lane's Prince Albert (2), Bramley's Seedling (2), Lord Derby (1), Early Victoria (2), Cox's Orange Pippin (5), and Worcester Permain (2). Again, most of the trees suffered from very slight Winter Moth attack, with a sprinkling of Tortrix larvae here and there. No apple aphides were noted, but a few *P. mali* occurred on two of the Cox's Orange, and a slight Thrip attack on Early Victoria.

Thirty bushes were left unsprayed as a control, namely Lady Sudely (6), Annie Elizabeth (3), Lane's Prince Albert (3), Newton Wonder (3), Bramley's Seedling (3), Beauty of Bath (6), and Worcester Permain (6). With the exception of the Newton Wonders, *Anuraphis roseus* was present on all varieties, the most heavily attacked being Lady Sudely, where on some of the trees 75% of the shoots carried large colonies. Beauty of Bath and Worcester Permain were also rather heavily attacked. A few colonies of *Aphis pomi* were also found on the Lady Sudely. All the trees showed slight Winter Moth and Tortrix damage, Thrips were observed on Annie Elizabeth, and small numbers of *Psylla mali* on Bramley's and Beauty of Bath.

In addition to the apple bushes, gooseberries and black currants were also sprayed as follows :—

Gooseberries. Keepsake and Whinham's Industry (36 bushes), sprayed with Carbokrimp; Whinham's Industry and Careless (54 bushes), with Mortegg; and Whitesmith and Keepsake (54 bushes) as a control.

Black Currants. Seabrook's Black and Edina (168 bushes), with Carbokrimp; Edina (56 bushes), with Mortegg; and Boskoop Giant (112 bushes) as a control.

The difference between the sprayed and unsprayed gooseberries was most striking. Every unsprayed bush, irrespective of variety, had from 75-100% of its shoots heavily attacked by *Aphis grossulariae*, growth was poor and stunted and the crop light. The sprayed bushes on the other hand were practically free from the aphis, only an occasional shoot being attacked. Growth was strong and vigorous, and the crop heavy. As regards the black currants, the effect of the spray was not so evident, no

aphides were found on the sprayed bushes however, while a few weak colonies of *Capitophorus ribis* were present on most of the unsprayed. A few bushes, both sprayed and unsprayed, were slightly damaged by larvae of the Gooseberry Sawfly.

General Inference.

The value of the sprays in controlling attacks of *A. roseus* and *A. grossulariae* was excellently demonstrated. There was no apparent control of caterpillar damage, and *P. mali* were not sufficiently numerous to allow any conclusion to be arrived at.

Plas Wye, Llyswen.

Altitude 100 ft. Spraying carried out on 21/2/27. Examinations made on 29/4/27 and 15/6/27.

The following trees were sprayed with Mortegg :—Worcester Permain (4), Peasgood Nonsuch (3), King Edward VII (2), King's Acre Bountiful (1), Blenheim Orange (1), and Crimson Bramley (1). Twelve trees were sprayed with Carbokrimp, namely, Beauty of Bath (1), Mr. Gladstone (1), James Grieve (1), Rival (1), The Queen (3), and Annie Elizabeth (5). Thirty-nine trees were not sprayed as a control, numerous varieties, too many to be detailed, being present.

The trees in this orchard are all ten-year-old half standards, which made detailed examination impossible. All the trees suffered from slight caterpillar attacks, and although no heavy attacks occurred except on one unsprayed Newton Wonder, which was about 80% defoliated, the extent of defoliation was obviously greater on the unsprayed trees than on the sprayed, the foliage of the latter being more healthy generally. No apple aphides were found on any of the trees. The trunk of one of the Peasgood Nonsuch, sprayed with Mortegg, was thickly covered with the Mussel Scale, *Lepidosaphes ulmi*. All the scales appeared to be killed. Seven unsprayed plums were included in the orchard; all suffered from attacks of *Anuraphis prunina*, the Leaf Curling Plum Aphid, variety King of Damsons being particularly heavily attacked.

General Inference.

Although the effect of the sprays was not so marked as at some centres, owing to the very slight degree of infestation, yet the treatment had been clearly beneficial.

CARMARTHENSHIRE.

Pibwrlwyd Farm Institute, Carmarthen.

Elevation 200 ft. Sprays applied on 8/2/27. Examinations made on 21/4/27 and 2/7/27.

In this orchard all the bushes—apples, gooseberries, and currants—were sprayed either with Mortegg or with Carbokrimp, no control bushes were left unsprayed and it is therefore impossible to estimate the value of the sprays in this particular demonstration. It may be said, however, that all bushes were remarkably free from insect attack. A sprinkling of Tortrix larvae occurred, the only severe attack being on one Allington Pippin, which was defoliated to the extent of about 80%. The only aphides found were two small colonies of *Anuraphis roseus* on Gladstone. No pests were found on gooseberries or currants.

General Inference.

The absence of controls made any demonstration of the value of the sprays impossible. Most of the trees, however, had suffered from heavy aphid attack in 1926, as was shown by the distorted growth, and although very light initial infestations were general in 1927, there is no doubt that the sprays contributed materially to the cleanliness of the bushes.

PEMBROKESHIRE.

Trevaughan, Haverfordwest.

Altitude 100 ft. Sprays applied on 28/2/27. Examinations made on 4/5/27 and 1/7/27.

Five Lane's Prince Albert were sprayed with Mortegg and five Bramley's Seedling with Carbokrimp. Control bushes were Newton Wonder (4), Gascoigne's Scarlet Seedling (1), Cox's Pomona (1). The only aphides found were three small colonies of *Rhopalosiphum prunifoliae* on one control Newton Wonder, *Anuraphis roseus* being quite absent. The Mortegg sprayed Lane's were remarkably clean, only a few Apple Sucker being noted. Winter Moth and Tortrix caterpillars were present in small numbers on all other bushes; the degree of attack was so small and the bushes so large that accurate estimation of the damage was not possible. It was quite evident to the eye, however, that the unsprayed bushes were the more badly damaged. Small numbers of Apple Suckers were present on most bushes.

In addition to the apple bushes, ten black currants and ten gooseberries were sprayed with Carbokrimp, ten of each with Mortegg, and five of each allowed to remain unsprayed as a control. All the sprayed black currants were free from any pest whatsoever, but about 5% of the shoots on the unsprayed bushes carried colonies of *Amphorophora cosmopolitana* or of *Capitophorus ribis*. As regards the gooseberries, one or two small colonies of *Aphis grossulariae* were found on most of the sprayed bushes. This was probably due to difficulty in carrying out a

thorough spraying owing to the thickness of the growth. About 10% of the shoots on the unsprayed bushes carried small colonies of the aphis.

General Inference.

The value of the sprays in controlling currant and gooseberry aphides was clearly demonstrated. The effect on apple aphides was not marked owing to the extremely light infestation. Control over Winter Moths and Tortrices was fair.

Taking the demonstrations as a whole, the value of Mortegg and Carbokrimp as winter washes was clearly shown, no differences in value between the two sprays being detected.

In all cases growth appeared to be more luxuriant on the sprayed trees and the foliage more healthy in colour. Where moss and lichen were present the sprays proved satisfactory cleansers.

As regards apple pests, practically complete control of aphides was obtained, but Apple Sucker infestations were too light for the beneficial effect to be clearly demonstrated. Excellent control of Winter Moth caterpillars was obtained in one centre, at the others it was slight or lacking. No apparent control of Tortrix larvae was obtained. It is evident that these sprays cannot be relied upon for caterpillar control. In the only case where Mussel Scale was present complete control was obtained. As regards varietal resistance, although the number of observations is too small to allow of definite conclusions, it may be of interest to note that Lane's Prince Albert and Allington Pippin appeared to be more susceptible to caterpillar attack, and Gladstone and Lady Sudely to aphid attack, than other varieties.

As regards currants and gooseberries the value of the sprays in controlling aphid attack was clearly demonstrated.

Trials in South Wales.

Examination and report by H. W. Thompson, M.Sc.

The results given below were obtained after examination of trials of three of the proprietary Tar Distillate washes put down in six centres in the South Wales area.

These spraying trials were carried out mainly with the idea of demonstrating to farmers and fruit growers in the area the efficiency of the sprays in destroying the wintering forms of several of the more important fruit pests. The effectiveness of these sprays has, of course, already been clearly proved in more detailed trials carried out elsewhere (1 and 2).

Of the six tests put down, one was in Monmouthshire and five were in Glamorgan.

The results given below were arrived at in conjunction with the County Horticultural Officers, after a joint examination of each test. Partly owing to late frosts, which checked the flowering of the trees, the examination of the orchards for results was held up until rather late—being made towards the end of May.

A factor which undoubtedly had an influence on the results obtained for the control of Winter Moth by these sprays was that as far as observations were made, the bulk of the Winter Moths emerged and laid their eggs before Christmas, i.e., before the sprayings were made. In the previous year, 1925-26, and also in 1923-24, the reverse was the case, and egg-laying was continued until the end of February. When the latter occurs, of course, correspondingly lower control results by these sprays are obtained.

The method used in determining results was similar to that used by Jary (1); ten marks being given to denote a particularly heavy infestation and correspondingly lower marks for infestations of lesser intensity.

It will be seen from the following Tables that Capsid Bug attacks were very slight except at the Usk test. Consequently, these tests give little evidence with regard to Capsid control.

TABLE OF RESULTS.

Sprayed Mortegg—Three Orchards.

Orchard No.	*Sprayed.*				*Unsprayed.*			
	1	*2*	*3*	*Average.*	*1*	*2*	*3*	*Average.*
Apple sucker	1	Trace	1	·7	7	Trace	2	3
Capsid ...	3	—	—	1	2	—	—	·7
Aphis ...	Trace	1	—	·3	1	5	5	3·7
Tortrix ...	2	1	1	1·3	4	2	2	2·7
Winter Moth	1·5	Trace	1	0·8	2	1	2	1·7

Orchard No. 1.—Agricultural Institution, Usk, Monmouthshire.

This orchard was sprayed about the 20th of December. The trees examined were half standard trees and half bush trees, about 10–12 years old. In this orchard a large number of the trees, which were being sprayed for the second year in succession, showed decided leaf injury. The leaves were small and curled and the unsprayed trees looked more healthy. This is difficult to account for, as different portions of the orchard were sprayed at strengths of 4%, 8%, and 10%. All appeared to show injury. It would almost appear that at the time of spraying, viz., December, owing to the very mild autumn and early winter, the trees were not thoroughly dormant. No other case of injury of this character has been met with. The examination was made on May 20th.

ORCHARD NO. 2.—RHOOSE, GLAMORGAN.

The trees sprayed and examined were about six years old. All had shown very decided insect injury the preceding year. The spray was applied in the last week in January. On these small trees it was, of course, easy to obtain thorough wetting, and the results obtained were correspondingly good. The trees were examined on May 11th.

ORCHARD NO. 3.—WEST ABERTHAW, GLAMORGAN.

About forty trees were sprayed—all of them standards about 8–10 years old. The spray was applied in the first week in February. Examined on May 11th.

Sprayed Carbokrimp—One Orchard, No. 4.

	Sprayed.	*Unsprayed.*
Apple sucker ...	0	2
Capsid ...	—	—
Aphis ...	0	2
Tortrix ...	2	6
Winter Moth ...	1	7·5

ORCHARD NO. 4.—LLANRHIDAN GOWER, GLAMORGAN.

A typical farm orchard of standard trees. Before spraying the trees had been heavily pruned, but thorough wetting with a knapsack sprayer proved rather difficult. The trees were sprayed during the first week in January and the examination was made on May 18th.

Sprayed Carbokill-egg—Two Orchards.

	Sprayed.			*Unsprayed.*		
Orchard No.	5	6	*Average.*	5	6	*Average.*
Apple sucker ...	1	0	·5	1	4	2·5
Capsid ...	0	0	0	0	0	0
Aphis ...	1	0	·5	2	2	2
Tortrix ...	2	1	1·5	5	3	4
Winter Moth ...	1	1	1	4	3	3·5

ORCHARD NO. 5.—PENRICE, GOWER, GLAMORGAN.

The spray was applied early in January at a strength of 8%. The spraying had been carried out under the direction of the head gardener and results were particularly marked, the foliage on the sprayed trees being very noticeably better. The trees were mainly small standards which had been well looked after. Date of examination—May 18th.

ORCHARD NO. 6.—GLAMORGAN INSTITUTION, PENCOED.

All the sprayed trees were young bush trees, and spraying was very thorough. The spray, a 10% wash, was applied in the middle of January. In this case the check consisted of old trees in an adjoining plot, which fact may have resulted in rather exaggerated control figures. Date of examination—May 24th.

Observations on the whole Test.

1. The three sprays used appeared to give about an equal measure of control against each of the pests examined for.

2. The sprayed trees appeared healthier than the unsprayed, the foliage being larger and a better colour, in addition to being cleaner, except in the case of Usk, where the foliage appeared to have been scorched, though insect control in this case also was quite satisfactory.

3. A knapsack sprayer appears to give hardly sufficient power for dealing with large standard trees, although it is quite effective for spraying bush trees.

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SEED TREATMENT AS A MEANS OF PREVENTING TURNIP FLEA BEETLE ATTACK.

By J. R. W. Jenkins, M.Sc.,
University College, Aberystwyth.

As is well known, flea beetle damage is most serious if the attack occurs when the young plants are breaking through the ground or when they are still in the seed leaf stage, an attack after the plants are in rough leaf being comparatively harmless. Among the various methods of preventing attack on the seed leaves is that of treating the seeds before drilling with paraffin or turpentine, but opinions as to the value of the treatment are very varied. Although ample evidence exists of successful prevention of attack by this method, there is unfortunately equally strong evidence of numerous failures, but as the writer has come into contact with many farmers who are strong supporters of the method, an attempt has been made to obtain some conclusive evidence on the matter.

It was assumed for the purpose of the experiments described below that seed treatment with paraffin or turpentine is, under certain conditions, successful and the experiments were designed to discover what conditions were responsible for the success or failure as the case may be. It was also assumed that the deterrent effect in successful cases is due to the seed leaves carrying up with them a sufficiency of paraffin or turpentine odour to make them objectionable to the flea beetle. The following possible contributory factors to the success or failure of the treatment were dealt with :—Effect of the treatment on seed germination; period elapsing between treatment and drilling; period elapsing between drilling and germination in the field; and the method of treatment.

Both laboratory and field experiments were carried out, and except where stated otherwise the method adopted for treating the seed was that usually employed by those farmers who include seed dressing as part of their normal practice. Briefly it is as follows :—The seed to be treated is spread out on a bag, sprinkled with paraffin or turpentine, and then rubbed with the palm of the hand until every seed has received a coating of the liquid. Care should be taken that the seeds are thoroughly wetted, about a teacupful of paraffin, and rather less of turpentine, to 1 lb. of seed being necessary to accomplish this. As will be shown later, there is no danger of using an excess of the dressing. After dressing the seed is allowed to remain on the bag until dried. In the writer's experience drying has always occurred overnight, but no attempt at sowing should be made until the seed is properly dry, or the drill will tend to clog.

With regard to estimation of attack in the field, a seedling was accounted attacked if it shewed any sign at all of flea beetle damage; degree of attack was not taken into consideration.

Experiments on the effect of the treatment on seed germination.

Since young seedlings are often eaten as they come through the ground, their remains being detected only after close observation, it was thought that if seed treatment had any deleterious effect on germination, crop failure from this cause might sometimes have been wrongly ascribed to flea beetle attack.

Kinaldy Green Top Swede seed was treated with paraffin in the usual manner, and twenty-four hours after treatment five separate hundreds were tested for germination capacity, the accepted methods of seed testing being employed. Five hundreds

of the same seed, but untreated, were also tested as a control. The result was as follows :—

Treatment.	*Average % germination.*
Untreated ...	87·0 ± 1·10
Paraffin ...	91·0 ± 1·00

Although the difference between the means is not within the experimental error, it is slight, and probably the only justifiable interpretation is that the paraffin treatment had had no deleterious effect.

A further experiment was carried out with Monarch swede, which was treated with paraffin, paraffin and red lead, and turpentine. Red lead and paraffin was included as this combination is used by farmers, the red lead being dusted over the seeds immediately after the paraffin treatment and then well rubbed in. The result of the experiment was as follows :—

Treatment.	*Average % germination.*
Untreated ...	73·2 ± 1·34
Paraffin ...	73·6 ± 1·50
Paraffin and Red Lead ...	75·8 ± 1·11
Turpentine ...	74·6 ± 1·13

Here again the only justifiable conclusion is that treatment has not been injurious, as although the average percentage germination of the treated seed is in each case above that of the untreated, the differences lie within the experimental error.

The next experiment was made to discover whether an overdose of the dressing would have any deleterious effect upon germination. Early White Turnip seed was soaked in paraffin and in turpentine for half an hour and then spread out to dry. It was then tested in the usual manner against untreated seed, with the following result :—

Treatment.	*Average % germination.*
Untreated ...	71·8 ± 1·08
Paraffin ...	77·6 ± 1·05
Turpentine ...	75·2 ± 1·8

Again the only justifiable conclusion is that the treatment has not been deleterious, and since it is unlikely that more drastic

treatment would be given under practical conditions unless by design, it may be assumed that provided the method of dressing outlined above is adopted, there can be no danger in using an excess of liquid.

It must often happen in practice that seed having been treated with the intention of drilling the following day, weather conditions delay the drilling for several days. The following test was made to discover whether lengthening the period between treating the seed with paraffin and turpentine, and giving the seed the opportunity of germinating, would have any adverse effect on germination. Early White Turnip seed was treated with paraffin and with turpentine in the usual manner, and five separate hundreds of each put to germinate each day subsequently for eleven days, and then every other day up to seventeen days from treatment. Every other day during this period five hundreds of untreated seed were put to germinate as a check on possible slight variations of temperature and humidity. The result was as follows :—

Interval between treatment and commencement of germination. DAYS.	*Percentage Germination.*		
	Paraffin.	*Turpentine.*	*Control.*
1	72	76	72
2	73	74	—
3	71	69	70
4	75	78	—
5	72	72	78
6	75	70	—
7	76	77	65
8	70	68	—
9	78	74	75
10	71	75	—
11	69	73	72
13	68	71	—
15	70	72	73
17	69	74	—
Average	72	73	72

The figures indicate clearly that prolonging the interval between seed treatment and drilling up to seventeen days has no deleterious effect upon germination. Its effect upon the efficacy of the treatment in warding off flea beetle attack will be dealt with later.

This experiment was also used to discover whether the inherent energy of germination is lowered by treatment. That this is not so is illustrated by the figures below :—

Interval between treatment and commencement of germination. DAYS.	*Percentage Third Day Germination.*		
	Paraffin.	*Turpentine.*	*Control.*
1	28	30	26
2	38	34	—
3	37	38	37
4	41	37	—
5	36	42	39
6	41	36	—
7	43	35	29
8	36	41	—
9	37	28	35
10	39	39	—
11	33	44	33
13	35	37	—
15	43	31	34
17	31	35	--
Average	37	36	33

Experiments on the effect of the treatment on Flea Beetle attack.

The first experiment was designed to obtain evidence, if possible, of the efficacy of the treatment and to test the effect of increasing the interval between treatment and drilling upon such efficacy. Since it was intended to test this latter point in a general manner only, and not to fix any particular period after which diminution of value might commence, two periods only were chosen, drilling one day after treatment, and seven days after treatment, with untreated seed as a control. Treatment of Toogood's Masterpiece Swede seed with paraffin was carried out in the usual manner, the dates being arranged so that the sowing of all seed could be carried out on the same day. Each batch of seed covered about six drills, and the seedlings were examined seven days after drilling. Counts were made of five separate hundreds in each of the three lots of drills, care being taken that the drills and portions of drills where the count was made corresponded for all the plots. The experiment gave the following results :—

Treatment.	*Average % attack.*
Control ...	$57 \cdot 0 \pm 1 \cdot 5$
7 days before drilling ...	$22 \cdot 8 \pm 0 \cdot 8$
1 day before drilling ...	$8 \cdot 2 \pm 0 \cdot 8$

As regards the general appearance of the seedlings, those from seeds drilled one day after treatment were of a better colour and in the opinion of the farmer were slightly more advanced than the remainder. This was not so noticeable in other experiments. As a check on these results, counts were made on five separate hundreds of seedlings in various parts of the main body of the field. These had been drilled a few days earlier than the experimental portion, and the seed had been paraffin treated the previous day. The counts gave an average percentage attack of 4·2 ± 0·35, which compares very favourably with the attack on the experimental seedlings similarly treated. This experiment affords excellent evidence that seed treatment with paraffin can be a very effective method of controlling flea beetle attack, and also shows that delay in drilling diminishes its value. Since the cause of the latter was probably due to evaporation of the paraffin prior to drilling, it was thought that soaking the seed for half an hour as in the germination tests described above might possibly enable the testa to absorb more paraffin and thus neutralise the effect of delayed drilling. Using paraffin and turpentine therefore the following experiment was devised to test the matter. Kinaldy Green Top Swede seed was soaked for half an hour in paraffin and in turpentine seven days before sowing, and was also treated with these substances in the usual manner one day before sowing. All seed was sown against an untreated control on the same day. The results were as follows :—

Treatment.	*Average % attack.*
Paraffin 7 days ...	27·5 ± 0·9
,, 1 day ...	11·2 ± 0·5
Turpentine 7 days ...	25·6 ± 1·1
,, 1 day ...	7·6 ± 0·7
Control ...	34·8 ± 1·2

Although the control obtained by treating the seed one day before drilling is not so great as in the previous experiment, it is appreciable. It would also appear from these results that should the period between treatment and drilling be prolonged, soaking the seed for half an hour instead of treating it in the usual manner does not preserve the efficacy of the treatment, since the percentage of attacked seedlings from seeds soaked for half an hour seven days before seeding, although lower than that of the control seedlings, is decidedly higher than that of the seedlings treated in the usual manner one day before drilling.

With regard to the third factor which it was considered might possibly affect the success or failure of the seed treatment, period elapsing between drilling and germination in the field, this is controlled by two chief factors, weather conditions and the inherent energy of the seed itself. That different varieties of seed do vary considerably in their inherent energy of germination was well illustrated in the germination tests with Kinaldy Green Top and with Monarch, described above. Four days after being provided with suitable germination conditions, untreated Kinaldy Green Top had an average germination of 64·9 %, and therefore a greater energy of germination than untreated Monarch with an average germination of 26·8 % in the same period, although the difference between the final germinations was not nearly so pronounced, being 87·0 % and 78·2 % respectively.

An experiment to illustrate the effect of weather conditions on speed of germination and upon the degree of control achieved by seed treatment cannot very well be arranged, but circumstances fortunately enabled the effects to be recorded by the results of experiments carried out in 1925 with the Kinaldy Green Top and Monarch Swedes referred to above. Monarch seed was treated with paraffin, with paraffin and red lead, and with turpentine on May 6th, and drilled against untreated seed as a control on the following day. The seedlings were examined for flea beetle attack sixteen days after, with the following results :—

Treatment.	*Average % attack.*
Control ...	78·6 ± 4·48
Paraffin ...	72·6 ± 4·11
Paraffin and red lead ...	72·0 ± 5·09
Turpentine ...	75·1 ± 4·47

In this experiment it is obvious that no control of the flea beetle was achieved. Kinaldy Green Top swedes were drilled on the 25th May, having been treated with paraffin in the usual manner the previous day. Untreated seed was drilled alongside as a control and the usual counts of attacked seedlings made seven days afterwards, with the following result.

Treatment.	*Average % attack.*
Control ...	61·2 ± 1·06
Paraffin ...	10·6 ± 1·74

Here a very appreciable degree of control was obtained.

A consideration of the two factors affecting speed of germination, i.e., inherent energy and weather conditions in these two experiments is of interest. Monarch seed, with a low energy of germination, was sown in the middle of a cold period with numerous hail storms. Germination was delayed, as is shown by the fact that although both Monarch and Kinaldy Green Top seedlings were examined for flea beetle attack at the same stage of growth, yet the examination in the case of Monarch took place sixteen days after drilling, and in the case of Kinaldy Green Top seven days after drilling. The result of this delay in germination was that no control of the flea beetle was obtained. On the other hand, Kinaldy Green Top Swede, with a high energy of germination, was sown at the end of a showery period immediately followed by a warm dry period; germination was rapid and an appreciable degree of control of the flea beetle was obtained.

It seems probable that the failure of the treatment when germination is delayed is due to the fact that the paraffin or turpentine is dissipated in the soil before the cotyledons are able to emerge. It was unfortunate that no soaked seed was included in this experiment in order to find whether the seedlings would be protected after delayed germination. However, having regard to the fact that as shown above, delaying the period between treatment and drilling materially reduces the efficacy of the treatment, even when the seed is soaked, it appears unlikely that soaking the seed would be of any great benefit when germination is delayed in the field. With regard to the method of treatment, it would seem clear that it is only necessary to use sufficient liquid to wet the seed thoroughly, and that no ill effects occur through using it to excess.

Conclusions.

The results of the germination tests make it clear that the methods of seed treatment adopted had no ill effect either upon energy of germination or upon total percentage germination, and that this still obtained when germination was delayed up to seventeen days after treatment. They also show that it is very unlikely that ill effects would occur through the use of excessive quantities of paraffin or turpentine. The fact that treated seed in almost every case possessed slightly higher germination than the untreated is probably due to the liquids used exerting a slight sterilising power.

The field experiments show that under favourable conditions seed treatment with paraffin or turpentine does achieve a very

appreciable degree of control over turnip flea beetles. The conditions necessary for success appear to be that sufficient liquid should be used to make the seed thoroughly wet; that drilling should take place as soon as possible after treatment; and that germination should not be delayed. They also show that soaking the seed for half an hour does not neutralise the ill effect of prolonging the period between treatment and drilling, and indicate that it would similarly fail to neutralise the ill effect of delayed germination.

It seems clear that seed treatment is a method of controlling flea beetle attack which farmers may be advised to include in their ordinary routine.

Although it is dependent for its success upon favourable conditions, given those conditions a high degree of control may be obtained, and moreover the labour and expense entailed are negligible.

Note.—Since the above article was written, it has been brought to the author's notice that some commercial turpentines may have a deleterious effect upon germination. If, therefore, it is proposed to use turpentine for seed dressing, its effect upon germination should first be tested. This can be done by treating a small quantity of seed in the usual manner and then placing it upon wet blotting paper or wet flannel to germinate. Care should be taken that the blotting paper or flannel is always kept thoroughly wet. Untreated seed should also be set to germinate as a check.

FURTHER TESTS OF POISON BAITS IN SOUTH WALES.

By H. W. Thompson, M.Sc.,

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The control of various pests by means of poisoned bran has been carried out extensively in the South Wales area during the past three years, having been applied on the following acreages and crops :—

Crops.	*Pest.*	*Acreage treated.*
Cereals ...	Leatherjackets	52
Cereals ...	Slugs	9
Cabbage, etc. ...	Leatherjackets	12
Cabbage, etc. ...	Surface caterpillars	5
Garden crops ...	Slugs	2

The bait used in each case was made up of 1 lb. of Paris Green and 20 lbs. of bran, moistened with approximately half a

gallon of water to make the poison adhere—this quantity being sufficient for dressing one acre.

Satisfactory results have been obtained in each case where the above mentioned bait has been applied, thus firmly establishing the efficiency of this particular bait. Owing to the fact, however, that it may not be considered desirable under certain circumstances to use an arsenical substance, such as Paris Green, and also on account of the undoubted prejudice against its use in many cases, it was determined in 1926 to continue tests on the same lines but using substances non-arsenical in character, with the object of finding, if possible, some other insect poison as effective as Paris Green but safer to handle and apply, consequently reducing any risk to stock or domestic animals which may arise owing to carelessness in mixing or storing the bait.[1]

During the early part of 1926, therefore, further trials were instituted, using bran poisoned with various alternative substances as a means of control for leatherjackets, and in 1927 against other pests also.

In a previous report (3) mention was made of a test of sodium fluoride which did not prove successful. Since then the following substances have been tried :—

1. Copper sulphate.
2. Derris powder.
3. Sodium fluosilicate.

Cases of leatherjacket injury were scarce in the spring of 1927, but as slugs were particularly numerous and their injury to a variety of crops very extensive, trials of the poison bait method of control were put down against this pest also. Two of the substances used have given promising results and are worthy of further trial.

I. Test of Cupper Sulphate.

This substance was included amongst those to be tried, as it has been considered that the effectiveness of Paris Green (Copper aceto-arsenite) might be due to some extent to the copper present, and if this proved to be the case that some other salt, such as sulphate, might also prove of value as a bait poison. Consequently a test was put down on a farm at Lisvane, Glamorgan. Half an acre of oats out of a field of three acres, all of which had

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[1] In view of the Protection of Animals Act, 1911, it appears that the poison bran may only be used where " all reasonable precautions " are taken " to prevent access thereto of dogs, cats, fowls, or other domestic animals ". Both for these and other reasons the circumstances in which the treatment is advisable are rather limited and those who wish to employ this control measure will do so on their own responsibility in conformity with the application of the aforementioned provisions to their own case.

failed owing to leatherjacket attack, was dressed with a bait made up of 10 lbs. of bran and ½ lb. of anhydrous copper sulphate. The application was made on May 4th, 1926. Subsequently the area was re-examined but no dead leatherjackets were found. A collection of fifty of them was made from the area. All were normal and were easily kept alive for some time in the laboratory. Neither dead slugs nor earthworms were found lying on the soil surface, as was always the case following a Paris Green bait application. It is possible that a heavy shower which followed shortly after the application was made may have interfered with its efficiency. Laboratory tests made, however, failed to show that this bait was in any way effective. This plot was subsequently dressed with the normal Paris Green bait.

II. Test of Derris Powder.

For the second trial Derris powder (which is the ground-up root of a leguminous plant known as Derris elliptica) was used in place of the copper sulphate. The bait was made up of 10 lbs. of bran and ½ lb. of Derris powder and applied to a second half-acre plot on the same field as above and at the same time. This plot was re-examined on May 6th and 7th and all the leatherjackets, both alive and dead—collected from representative areas over the plot—were taken in to the laboratory for examination, with the following results :—

Number of living larvae 46.
Number of dead larvae 82.

In addition a further twelve died in the laboratory within four days. This substance, although not on this occasion giving as good results as the Paris Green bait, is obviously of definite insecticidal value when used in this way.

On this plot numerous earthworms were found lying dead on the surface and also some slugs. Derris powder clearly does not render the bait distasteful to the pests named, as appeared to be the case with Sodium fluoride (3).

The remainder of the field was dressed with the Paris Green bait and resown, following which a good crop was obtained, the bait giving as good a measure of control as on other occasions where used.

III. Test of Sodium Fluosilicate.

This substance has been shown by Langford (2) to be as effective a bait poison as Paris Green against grasshoppers. It has also been shown by Ingram (1) to be very effective as a control for Blister Beetles on Soy beans. Consequently it was decided to try it out against other pests. No suitable opportunity

occurred during 1927 for testing out bait poisoned with this substance against leatherlackets, but a trial on a scale of one acre against slugs was put down on May 9th, 1927, on a farm near Cardiff. The field was one of three acres and the crop (oats) was a complete failure owing to slug injury. The poison bait was made up in the same proportions as before, viz., 20 lbs. of bran and 1 lb. of the poison (sodium fluosilicate), moistened to ensure adherence of the poison to the bran.

This bait undoubtedly gave a fair measure of control. Of the slugs collected from this field on May 10th nearly half were found to be dead. Numerous dead earthworms were also found.[2] A collection of slugs from representative areas was made and examined in the laboratory. In this case soil samples were also brought in for more careful examination, as the smaller dead slugs are easily overlooked in the field. The result of this collection and subsequent examination was :—

No. of slugs collected	...	51
,, ,, ,, living	...	29
,, ,, ,, dead	...	22

The examination extended over several days. No difficulty was experienced in keeping other slugs from untreated areas alive in the laboratory for the same length of time.

The remainder of the field—two acres—was dressed with the Paris Green bait. This proved to give very similar results to the above. From this plot thirty-three living slugs and twenty-three dead were collected.

At the time of this trial the weather was very dry and there is no doubt that this is an important factor in the use of a poison bait against slugs. During moist weather the slugs come to the surface to feed, whereas during dry weather much of their injury is below ground, or, as in this case, where the field was ploughed-up grassland, many of the slugs remain in the old turf. The field was subsequently worked down again and resown. No further injury developed and a satisfactory crop was obtained.

On two other occasions where poison bait was used against slugs almost complete control was effected.

The first case was on a field of six acres near Chepstow, where Winter wheat had been damaged to the extent of 30 per cent. or so by slugs. Paris Green bait was applied on April 18th and four days later the field was harrowed and heavily rolled. No further injury developed and the crop recovered, the farmer reporting

2 This latter circumstance appears to be some guide to the efficiency or otherwise of the poison bait used.

numerous dead slugs lying on the surface following the application.

A further test of Paris Green bait was put down during May, 1927, in a garden at Ferndale, very heavily infested with slugs. Almost complete control was obtained, favourable moist conditions at the time of application ensuring the satisfactory working of the bait.

These field tests of poison baits for the control of slugs were made after promising laboratory results had been obtained. Three large boxes partly filled with moist soil had twenty-four slugs introduced into each.

Box 1 had a thin sprinkling of Paris Green bait applied to the surface of the soil; Box 2 a similar sprinkling of sodium fluosilicate bait, and Box 3 a sprinkling of unpoisoned moistened bran. All the boxes were covered. Dead slugs lying on the soil were removed daily and at the end of the week the soil was examined with the following results :—

	Poison.	*Dead slugs.*	*Living slugs.*
Box 1.	Paris Green	17	7
,, 2.	Sodium fluosilicate	15	9
,, 3.	Control	2	22

With regard to the mixing of the various baits used, uniform mixing is much more easy to be sure of in the case of Paris Green than of the other substances tried, on account of the green colour which the bait assumes—uniformity of colour ensuring even poisoning of the bait.

A further field test of sodium fluosilicate bait against surface caterpillars was put down on June 29th, 1927, at Llangibby, Monmouthshire. An acre of mangolds on which injury due to this pest was developing was treated with the bait, the strength and quantity per acre used being as before. The acre dressed covered all the badly affected part of the crop. The remaining two acres, being only slightly affected, were not dressed. Unfortunately it was not found possible to re-visit the field at once for careful examination, but the farmer was satisfied that no further injury developed and reported dead caterpillars lying on the surface of the ground following the application.

A second visit was paid to the field a week later and careful examination made of the treated area, but no surface caterpillars could be found on this occasion.

The abnormally bad weather conditions during the summer of 1927 interfered very considerably with the progress of the work

recorded above and rendered it impossible in the case of some of the tests put down to obtain results of definite value. When opportunity occurs it is hoped that it will be possible to repeat some of these.

Conclusions.

The tests so far made appear to show :—

1. The efficiency of the poison bait method of control for various pests.
2. Copper sulphate does not appear likely to prove an effective bait poison.
3. Derris powder gives moderately good results.
4. Sodium fluosilicate as a bait poison is promising and is worth further trial.

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SOME EXPERIMENTS FOR THE CONTROL OF MANGOLD FLY.

BY C. L. WALTON, M.Sc., PH.D.,
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During the past few years more or less severe infestations of the mangold crop by the larvae of the Mangold Fly (*Pegomyia betae*) have been general in N. Wales, more particularly in the seedling stages; and very numerous complaints have been made by growers, who state that in a number of cases the crop was ruined, more especially where the infestation of both the seed leaves was coincident with a period of drought. In many other instances the crop was badly injured or retarded, even where the attack was either less severe, or weather conditions were more favourable.

With a view to determining what could be done, a series of preliminary experiments was initiated, of which these notes are the result. It is felt, however, that some apology is due for their appearance in an incomplete form, and this is furnished by the departure of the writer from North Wales. Experimentation followed three lines—(A) Dusting, (B) Spraying, and (C) Rolling.

Experiments in 1926.

Ova were laid as soon as seedlings appeared. The first hatching was noted on 24-26 May and by the latter date ten to fifteen per cent. of plants at Aber, etc., were mined. The weather at this period was fine, warm and dry and infestation increased to a maximum of 38 per cent. of *plants*. A count of infested leaves gave fifty-three ova on forty-three leaves. Experiments were commenced at three centres, (1) Aber—two separate farms, (2) Madryn Farm School, near Pwllheli.

(1) ABER. Tai'rmeibion (Mr. W. O. H. Ellis) and College Farm. At both centres plots of ten rows, twenty yards in length, were alternated with equal sized controls.

At all three places Green tar oil two per cent. dust and two per cent Nicotine sulphate dust, applied with hand bellows, once, twice and (in one case) thrice, both before and after rain, had no deterrent effect on either oviposition, or on subsequent hatching, counts being equal on twice dusted and control plots.

Mangolds and sugar beet were both included in these trials. Very numerous counts were made on the plots (and the controls), running into thousands of plants.

Nicotine sulphate dust was used up to fifty lbs. per acre (rate) without effect.

Heavy rain and cool weather set in and the plants made rapid growth, the damaged seed leaves were shed, and a month later it was difficult to find signs of attack.

(2) At MADRYN FARM SCHOOL, the Lecturer in Agriculture, Mr. Edwin Jones, B.Sc., carried out the following experiments at my suggestion, and with material supplied :—

(i) Dusts—result as above.

(ii) Sprays :

(A) *Nicotine sulphate and soft soap* ($2\frac{1}{2}$ oz. nicotine sulphate, 1 lb. soap (soft), 10 gallons water).

(B) *Paraffin emulsion* (1 pint White Rose paraffin, 1 lb. soft soap, 10 gallons water).

The treatment was applied as soon as the plants were well through and were in plots of ten contiguous rows of twenty yards each. Mr. Jones and myself examined the plants 12/6/26—twelve days after treatment (and just after heavy rain).

In all 1,600 plants (3,200) leaves were carefully examined.

(i) *Nicotine sulphate dust.* 200 plants = average infestation 14·5 % plants.

(ii) *Paraffin emulsion.* 800 plants = average infestation 2 % plants.

(iii) *Nicotine sulphate spray.* 500 plants = average infestation 8·4 % plants.

(iv) *Controls.* 600 plants = average infestation 16·6 % plants.

The controls were counted in batches between each plot and at the ends.

Experiments in 1927.

The infestation was by no means so general, but was heavy in S. Caernarvonshire, and fairly so in parts of Anglesey. As in 1926, the initial attack died out by the end of June and little subsequent infestation was noted, except in S. Caernarvonshire. Infestations of 41 % of plants in Anglesey and 66 % in S. Caernarvonshire were recorded. The weather conditions were very similar to 1926, cool, wet weather setting in during June, with subsequent rapid growth of the crop.

In view of the poor results obtained in 1926 no further dusting experiments were undertaken. At Madryn Farm School, Mr. E. Jones repeated the spraying experiments, using (*a*) Paraffin emulsion, and (*b*) Bordeaux mixture.

(1) *Spraying* was done on 23/5/27 at the same strength as in 1926, and thirteen contiguous rows of 100 yards each were treated, the remainder of each row being left as control. The plants were seedlings. Counts were made 3/6/27.

The treated areas showed an infestation of 7 % and the controls 30 %.

(2) *Bordeaux Mixture* (sprayed) gave an infestation of 21 %. Controls showed the same rate of infestation as (1).

Rolling.

In 1924 I examined a crop on a Flintshire farm, which being very heavily infested was rolled by the farmer at singling time a few days previously. The crop had completely recovered and only one or two living larvae could be found in the leaves despite careful search. The land was sandy and the crop sown on the flat. Subsequently, in 1925, I suggested this method to a number of growers, several of whom rolled part of their infested crops. All reported very favourably, including one who rolled on heavy land in very rough condition during dry weather.

In 1926 further similarly successful trials were reported.

In 1927, Mr. W. Owen, Afonwen Farm, near Criccieth, Caernarvonshire, carried out a trial at my suggestion. The variety was Yellow Globe, two acres sown on May 1st. The infestation on 2/6/27 was 66 % of plants, which were in the 4-6 leaved stage. Several leaves per plant contained larvae.

One acre was rolled on 11/6/27 with a stone roller covering two ridges at a time. The land was light, but very stony, more especially on the lower slopes, where the stones were large and numerous. The crop was examined 19/6/27. The rolled area yielded two living larvae per 100 mined leaves, whilst on the unrolled portion larvae were present in almost every mined leaf examined. Mr. Owen considered that although the plants were not visibly harmed by the rolling, yet growth was retarded to some extent, for a time at least.

Conclusions.

1. It would appear from the foregoing that the application of Green tar oil and Nicotine sulphate dusts was not successful in deterring attack, neither was a spray with Bordeaux mixture.
2. That spraying with either Paraffin emulsion or Nicotine sulphate does not injure the seedling plants, and affords a very considerable degree of protection, but should be done as soon as the plants are through.
3. Rolling would seem to offer a reasonable and effective method of control, and if carried out before singling, does not harm the plant.

Considerable further experimentation is desirable.

The writer wishes to thank those who assisted in the experiments in a very efficient manner and without whose help the experiments could not have been carried out.

AFFORESTATION IN WALES.

THE WORK OF THE FORESTRY COMMISSION.

Throughout the mountainous parts of Wales there can be found thousands of acres of land admirably suited to the growing of coniferous trees; some of this is bare hill-land, and some now carries a growth of scrubby hardwoods; nearly all is more or less grazed by sheep and, in some cases, also by cattle and ponies. Most of the scrub areas provide poor feed and any grazing value they possess can be attributed mainly to the shelter they afford; if such areas, together with a considerable proportion of the bare hillsides, be afforested, they can undoubtedly absorb more labour and make a better financial return than under the existing utilization. The same applies with especial force both to unhealthy sheep-walks, which are often admirably suited for tree-growing, and also to mountain pastures where the adjacent ffridds and meadows have been neglected, do not now justify the

cost of putting into full production, and cannot therefore provide for the wintering of such head of stock as can be carried on the uplands during the summer months. The conditions which obtain have thus permitted satisfactory progress by the Forestry Commissioners since their establishment in 1919; acquiring land in the open market and without recourse to their compulsory powers, their holdings in Wales now amount to approximately 44,000 acres, comprised in eighteen units or "Forests" which are distributed throughout eight counties and include also the old Crown estates at Tintern (Mon.) and Hafod Fawr (near Maentwrog). The largest holdings in any one county are in Merionethshire (12,400 acres), and this county has also the largest number of forests (four). Extensive areas are now under negotiation and special attention is being paid to those counties where acquisition has so far proceeded slowly.

By April, 1927, some 12,400 acres had been planted, mostly during the preceding four or five years, the maximum area being in Glamorganshire with nearly 3,000 acres spread over three forests. During the season 1927-28 it is proposed to plant some 3,800 acres, with a maximum county programme of 693 acres, in Montgomeryshire (two forests), Merionethshire with 680 acres distributed over four forests has the second largest programme.

The preparation, planting, and maintenance of the 12,400 acres dealt with to date will have found work for from five to ten times as many men as this area would have supported had it remained under its original utilization, and it is anticipated that every 200 acres planted will, as a minimum, afford permanent support for one family, whilst this figure will undoubtedly be largely increased when thinning operations commence.

The types of land acquired comprise almost all classes of mountain land, not excluding wet, peaty areas of little agricultural value but suitable for drainage and thereafter capable of growing excellent spruce, or the steep and often rocky slopes which will support the growth of larch and Douglas fir. Occasionally there occur small areas suitable for the growth of oak and other hardwoods, and in such cases these species are invariably employed, but this type of land can rarely be secured at the price which the Commissioners are permited to pay.

In order to secure efficiency and economy the Commissioners must lay their plans several years in advance, and many preparations must be made, both as regards the supply of foresters and foremen and the building up of a staff of trained labourers. This alone involves the acquisition of land well before it is actually required for planting, but the latter is also doubly

necessary in order that the infliction of hardship on sitting tenants may be avoided. As all land not planted or in course of preparation remains tenanted to the latest possible date no losses are incurred to offset the advantages of advance acquisition, and when a tenancy is finally determined the Commissioners exclude from their planting areas all small parcels of good agricultural land, converting these to small farms, if suitable, or establishing thereon Forest Workers' Holdings, which are tenanted by employees, who are guaranteed either whole-time or seasonal work, and are thus assured of a certain revenue other than the receipts from their land. Where suitable dwellings and buildings do not already exist such holdings are equipped with re-constructed, adapted, or new buildings, and the holder does not have more than ten acres of good land, although occasionally he is provided also with rough land as out-run; thereby the best use of the good land and the efficient utilization of poor areas which are unsuitable for planting is secured, whilst a staff of trained workers resident on the area and having a real personal interest therein will be built up. Some sixty-seven of these holdings have been established to date and a further seventy-two are already projected or actually in course of establishment; of these the greatest number already created is on the three forests in Merionethshire, where there are twenty holdings; Caernarvonshire comes second with nineteen holdings on two forests. It is in the latter county and also in Merioneth and Montgomery that the most rapid development of the holdings scheme appears probable.

Many owners have availed themselves of the Commissioners' Afforestation Grant Schemes, under which landowners may secure a free grant of £2 per acre for every acre planted with conifers, £4 for every acre of hardwoods, and a further grant of £1 per acre (in exceptional circumstances £2) for every acre which has to be cleared of worthless scrub prior to planting. Full particulars of these grant schemes can be obtained from the Assistant Commissioner (E. and W.), 1, Whitehall, London, S.W. 1, and it seems certain that even greater advantage will be taken of them when the absence of irksome restrictions, red tape, vexatious interference and delay is fully appreciated. Prior sanction, sound sylviculture, and good work in its application, alone are required. Advice can always be secured on application to the Divisional Officer, Forestry Commission, Castle Chambers, Shrewsbury, who is required to make a small charge for visits which cannot be carried out in the normal course of his duties.

O.J.S.

ROOKS AND AGRICULTURE IN MID AND NORTH WALES.

By C. L. Walton, M.Sc., Ph.D.,
University College, Bangor.

During the period 1913-16 the writer conducted a Survey of the Agricultural Zoology of the country about Aberystwyth. The area examined comprised about 250 sq. miles of North Cardiganshire and the adjacent borders of Montgomeryshire, and included Plynlymon and much of the natural sheep pastures that surround that mountain mass, as well as the wooded valleys of the Rheidol, Ystwyth, etc., and the more highly cultivated coastal region of which Aberystwyth is the focus.

During the Survey some 250 farms and holdings were visited and no less than 100 complaints were received as to loss caused by birds of various species to farm crops, garden or poultry yard. It is proposed here to refer only to those relating to rooks.

At that time the rook (locally called crow) was very abundant in the area examined, and the writer was aware of sixteen rookeries. Mr. J. R. W. Jenkins, M.Sc., the present Adviser in Entomology, states that the position is now much modified, and that rooks are by no means so abundant at the present time. The largest rookeries were at Gogerddan, in the centre of the area, and Mabws, just on the southern boundary. Both these were examined in May, 1916, and in the case of the former 300 nests were counted, whilst in the latter 280 to 300 were present in the main rookery and subsidiary colonies. It was difficult to tell how many were actually in use, and 250 were assumed to be so. If we allow two adults and an average of three young as leaving the nest (a conservative estimate, since according to Coward the rook lays from four to six eggs), we should have an active population of 500 adults and 750 young; total 1,250. If we attempt a total estimate of the (then) population of the area, we arrive at the following :—two rookeries of 250 nests, seven with 100 nests and seven with 50. Total 7,750. Probably we should be fairly safe in estimating the summer population of rooks at 8,000 to 9,000, as there were several rookeries near the boundaries of the areas and the birds from there spent much of their time within it.

During the period of the Survey I received thirty-eight complaints as to damage by rooks, the chief being the devouring

of seed corn, stealing potatoes, and pulling up young swedes (in search of wireworms, etc.). Farmers were strongly of the opinion that rooks were too numerous. The flocks were generally accompanied by jackdaws in considerable numbers.

In the summer and autumn of 1915 the larvae of the Garden Chafer (*Phyllopertha horticola*) were present on some of the mountain pastures in enormous numbers and these attracted the attentions of great numbers of rooks (and other birds), who completely dug up acres of infested grass lands in search of them.

To turn to North Wales during the period, December, 1920, to September, 1927, the writer occupied the post of Adviser in Agricultural Zoology for the four counties of Anglesey, Caernarvon, Denbigh and Flint, and throughout the work in that area the Survey method was constantly followed. The total area is approximately 1,750 sq. miles, and during the period certainly not less than 1,200 different farms and holdings were visited (many being visited more than once). A consistent attempt was made to compile a map of rookeries and a census of rooks, and in all ninety rookeries were noted and mapped. These come in the following categories :—three of 400 nests, twelve with from 150 to 200, twenty-seven with about 100, twenty-seven with about fifty, and twenty-one with less than fifty nests, giving a total of approximately 8,000 nests and (at the same conservative estimate of two adults and three young) a summer population of, say, 40,000. This in an area seven times greater than the one surveyed about Aberystwyth. An equal rate would have given North Wales about 60,000 rooks. Furthermore, the rookeries, when mapped, show very little of the concentration found in the Mid Wales area, where they were very much concentrated. This means less competition in feeding and wider feeding ranges.

These conditions seem to be reflected in the relatively small numbers of complaints received in North Wales, there being not more than twenty from very widely separated places. It is not claimed that the rookery list for North Wales is complete, and a number may have been missed, nevertheless the list must be fairly complete.

In enumerating nests there are two precautions needed, firstly, counts made earlier than April are liable to inaccuracy, since in wind-swept situations quite half the nests may be blown out during winter. The writer has made comparative counts of such rookeries in February and April. Secondly, once leafage becomes really dense, accurate counts are very difficult in some instances.

The damage complained of in the North is similar to that given for Mid Wales.

Estimates of rook population are to be found for Dumfriesshire (1) and Lanarkshire (2). Ritchie states " Thus, although South-East Lanarkshire, containing less than 10 per cent. of the country's arable land, suffers heavily, the grain crops of the north-western section, with over 90 per cent. of the arable land, suffers scarcely at all, yet the number of rooks in each does not differ greatly, the former area containing some 10,830 nests, the latter 8,552. The secret of the difference lies in the fact that the north-west section contains much pasture and hay land, which affords an abundant supply of insect food preferred by the rook, so that the grain escapes, whereas the less fertile south-eastern section is deficient in meadow land ". It looks as though the above explanation also applies to North Wales, where, as already stated, the rookeries are well spaced out.

Another matter may be mentioned here, namely, the rook as a harbourer of the Gape Worm, *Syngamus trachealis*. The writer, when in Mid Wales, noted the great prevalence of this parasite in chickens, and the matter has since been dealt with by Lewis in two contributions (3) and (4), in which he emphasises the importance of starlings in this respect. As regards rooks, he states (4 p. 46) " No detailed investigations have been made into the extent to which pheasants, thrushes, rooks, jays and other wild birds help to distribute *S. trachealis*, but it is evident that these birds must be considered as carriers to a certain extent at least, for the gape-worm has been collected from their tracheae on a few occasions ".

A case noted in Anglesey in May, 1925, throws some further light on this point—that of a country house surrounded by trees in which were from 125 to 150 rooks' nests. The owner was unable to rear chickens anywhere about the place except in a large old greenhouse which was utilised for this purpose. One brood of chicks hatched and kept outside were dying out at the time of visit, and two that died that day yielded thirty-eight and thirty worms (♂ and ♀) respectively. At my suggestion, Mr. W. Norman Jones, B.Sc., visited the place a little later, and found a number of young rooks gasping on the ground beneath the trees. Two of these were brought into the laboratories and yielded large numbers of worms—unfortunately the exact numbers, although taken at the time, are not now available.

A sporting tenant commenced pheasant rearing in Flintshire in a field alongside a rookery, and suffered heavy losses. No

actual proof as to infection in these rooks was ever obtained, however, and the case remains merely suggestive.

1. GLADSTONE, H. S. Notes on Birds of Dumfries-shire. *Dumfries Nat. Hist. Soc.*, 1923.

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3. LEWIS, E. A. Starlings as Distributors of " Gapes ". *Jnl. of Helminthology*, Vol. III, No. 2, May, 1925, pp. 81-82.

4. LEWIS, E. A. Starlings as Distributors of " Gapes ". *Ibid.*, Vol. IV, No. 2, May, 1926, pp. 43-48.

ABSTRACTS, REVIEWS, AND BIBLIOGRAPHICAL NOTES.

AGRICULTURAL ECONOMICS.

Abstractors :

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ACCOUNTS AND COSTS.

An Economic and Financial Analysis: East Anglian Farms.

Report 6. By J. A. VENN and G. G. GIANETTI.

Report 8. By R. McG. CARSLAW and G. G. GIANETTI, of the School of Agriculture, Cambridge. Price 1/- each.

These are additions to a series of publications on the economic and financial analysis of farm enterprises that have been issued by the Farm Economics Branch of Cambridge School of Agriculture. Report 6 deals with thirteen farms (Michaelmas) 1925-26 and the results for eleven of these are dealt with for the third year. The analysis for the first and second year appeared in Reports 1 and 3. Report 8 gives the results for seven farms (Ladyday) 1926-27, five of which are reviewed for the third year in succession. The first and second years' results were published in Reports 2 and 4. Tabular statements showing the cost of crops and horse labour with various other financial and economic data is given and Report 6 gives the component costs per acre (for individual farms) of the barley crop for 1926 and the milk costs for two farms. The reports also show profits and losses. The distribution of the " Net Output " is here given :—

	Distribution of Net Output.			
	Labour. %	*Rent and Rates.* %	*Profit.* %	*Total Net Output.* %
Michaelmas Farms :				
15 (1924–25)	51·0	20·0	29·0	100
18 (1925–26)	56·4	21·4	22·2	100
Ladyday Farms :				
6 (1924–25)	57·0	26·0	17·0	100
6 (1925–26)	65·0	32·0	3·0	100
7 (1926–27)	76·0	32·0	— 8·0	100

The Reports, providing as they do the results for a number of farms over a series of years, are very valuable and especially to anyone who is interested in farm costings and financial results. J.P.H.

An Economic Investigation of Devon and Cornish Agriculture.

By W. HARWOOD LONG. Price 1/-. Seale Hayne College of Agriculture, 1927.

A report on the analysis of farm cash accounts in the counties of Devon and Cornwall. The enquiry covers the period 1923-24 (thirty-one farms), 1924-25 (forty-five farms) and 1925-26 (sixty farms). The results are summarised according to localities, size of farms and periods and a separate study is made of the thirty-three farms which cover the whole period of the investigation. It is shown that the total profits for all the farms reviewed over the three years were £2,970 17s. 3d., equivalent to 0·7% of the valuation. All this profit occurred in the one year (1924-25), when the return on the valuation was 6·9%. The losses in the years 1923-24 and 1925-26 represented ·03% and 3·81% of the valuation and these losses were affected by a fall in the valuation during these years. J.P.H.

A Successful Norfolk Poultry Farm. 1922–26.

Report No. 5. By R. McG. CARSLAW, School of Agriculture, Cambridge. Price 1/-.

Report 5 is an account of the development, difficulties and successes of a poultry farm situated on a light Norfolk soil. The sections in this report deal with capital, outgoings, labour, foods and feeding, treatment of runs, huts, buildings and appliances, diseases and risks, breeding and selection of breeding hens and the returns on this farm. Several useful tables are inserted in the report—one showing the monthly record of eggs for the year 1925-26, the average number of eggs produced per bird and the average price received per egg sold; another gives the balance sheets for each year and another the revenue account for the whole period. The figures show that the balance to cover interest on occupier's capital, unpaid labour and profits has increased from £445 13s. 9d. in 1923 to £845 15s. 11d. in 1926. The result is all the more interesting in that the occupier was in no way connected with the soil before he embarked on this undertaking. The report is of practical value in that it gives an insight into the management of a poultry farm on which both the organisation and profits have been very satisfactory. J.P.H.

Cost Accounts Applied to Agriculture: An aid to more productive farming.

J. S. KING. Oxford University Press, 1927.

This book is in part a critique of systems of agricultural costing hitherto used in this country, in part a statement of some principles of agriculture and of economics which underly any costing system, and in part a statement of an alternative system of costing. The system of costing individual crops or products, where these are intermediate in the full process of production, is criticised. It is suggested that the first aim in cost accounting as applied to farming should be the collection of " basic " costs, i.e., *quantitative* statements of labour, etc., involved in production and of the yields in terms of quantities of crops or livestock produce obtainable from varying applications of capital under the conditions prevailing on the farms in an average year. The accounts for the elucidation of costs must be kept in terms of money, but the basic costs should appear as the physical equivalents of outlay wherever possible. " Basic " costs can only be determined by considering costs over a

number of years. Principles of valuation are considered, and the bases of " apportionment " of uncertain quantities between one department and another, with the treatment of processes of maintaining fertility, are discussed at length.

The organisation of accounts which is suggested is that of the " sectional enterprise " rather than that of accounts for individual crops or products. Examples of results for different types of farms are given. A section deals with the processes of accounting on this principle.

A large part of the matter of 170 pages is theoretical, but the book is of high critical and suggestive value. A.W.A.

The Economy of a Norfolk Fruit Farm, 1923–1926.

By C. W. B. Wright and R. McG. Carslaw. Report No. 7. School of Agriculture, Cambridge. Price 2/-.

This is a very detailed and interesting study of a Norfolk fruit farm. The Report is divided into two sections. The first section deals with the accounts, labour, land wastage and interplanting, the methods of cultivation, yields and prices of strawberries, black currants and apples, and the second section is devoted to the cost of marketing the crops (picking, packages, rail and freight and market charges). While the investigation covers the period 1923-26, cost accounts are only available for the 1925 and 1926 crops. These are set out in detail in the tables included in the Appendices. The following shows the principal features:—

	Strawberries.	*Black Currants.*	*Apples.*
Cost of harvested acreage (per acre) ...	£30 5 0	£30 13 0	£19 2 5
Yield (cwts. per acre) ...	37·5	13·9	20·1
Cost of picking, carriage, etc. (per cwt.) ...	15 7½	£ 1 0 9	6 0½
Total cost of crop, per acre	£59 11 2¼	£45 9 8½	£25 3 10½
Total cost of crop, per cwt.	£ 1 11 10¾	£ 3 6 1	£ 1 7 11
Receipts, per acre	£88 10 1½	£58 6 9	£20 15 2¼
Receipts, per cwt.	£ 2 6 2½	£ 4 4 0	19 8
Net return, Profit, per acre	£28 18 11	£12 17 0	
Net return, Profit, per cwt.	14 4	17 11	
Net return, Loss, per acre			£ 4 8 8
Net return, Loss, per cwt.			8 3

The Report, apart from its value to the horticulturist, the fruit grower and the student of costs, will serve a very useful purpose in providing a basis for future studies of this nature. J.P.H.

Sugar Beet in the Northern Counties (1926).

By J. H. Dinsdale and J. Ll. Davies.

A report dealing with the results of an investigation into the costs and returns of growing sugar beet on ten farms in the Northern Counties. The average results for all the farms shows that the cost, including delivery to the factory, is £20 15s. 11d., with a range of from £17 4s. 8d. to £23 19s. 9d. per acre. J.P.H.

Sugar Beet: The results of an enquiry into the costs of production, yields and returns in 1924.

Sugar Beet: Costs and returns for the year 1925–26.

By A. Bridges and R. N. Dixey. Agricultural Economics Research Institute, Oxford.

These reports contain the results of enquiries into the costs of production, yields and returns of sugar beet on certain farms in 1924 and 1925. The first study is based on the costs found for thirty-four and the second on those for fifty-three farms. These costs have been grouped according to variations of soil, with, in addition, a grouping according to districts in the second report. The costs of the crop and the returns are fully discussed and a very detailed study has been made of the labour costs for the 1925-26 crop. In the first monograph the effects of the introduction of sugar beet on the farm routine, and the farming system is dealt with and the question of labour, capitalisation, and the possibilities of future economies and improved returns are discussed. The second monograph is mainly concerned with a discussion on the costs and the returns, and discusses the comparative results for the two years of study. Attention has been drawn in both publications to points which seem to offer scope for improvement and they contain a great deal of information which should prove of value to growers and others interested in the sugar beet industry. J.P.H.

AGRICULTURAL CO-OPERATION.

Agricultural Co-operation in Denmark.

Chris. L. Christensen. *Bulletin*, 1266, United States Department of Agriculture, 1924.

This comprehensive survey demonstrates the principles underlying a movement which is often held up as a model to the rest of the world. The historical introduction shows that, as elsewhere, co-operation was the child of necessity. The growing production of livestock and their products for export necessitated a new form of organisation if foreign markets were to be captured and connections maintained. In no sphere of co-operative activity has the Dane been more successful than in the operation of creameries, bacon factories and egg collecting societies which generally operate on commodity lines. As the result of the work of these societies Denmark has won a reputation on British markets for reliable products which can withstand the competition of all other countries. This has been secured by taking practical and bold steps to organise production and marketing on a sound footing.

Realising the importance of meeting the consumers' requirements, the societies through their central federations make a close study of market demands, and production is carried on with these in view. The establishment and maintenance of grades by continual testing and competition between societies enables a high standard of produce to be maintained. The degree of standardisation has progressed so far in butter and bacon that all exports are sold under the *Lur* brand, which is a guarantee of quality and uniformity.

The intimate connection between sound marketing and intelligent production has been realised, and the co-operative societies have largely directed methods of breeding and feeding within the Kingdom. The basis of payment for supplies to members, by putting a premium on the

production of the desired article, forces the farmer to realise the connection between quality and price. Milk is bought on butter fat analysis, bacon pigs on deadweight grades, and eggs by weight.

The structure and interrelation of the network of local societies, central intelligence and sales organisations are all similar and aim at controlling the quantity, quality and movement of the product handled. A binding contract varying in length up to ten years to supply to the society, whether composed of individual farmers or of other societies, is the basis of the Danish co-operative machinery. Membership of a society also involves undertaking unlimited liability for the debts of the society on the basis of trade done with or shares and reserves held in the society. The membership contracts, together with the assumption of unlimited liability, explain the method of capitalisation which has been adopted. The societies are all non-stock and derive their initial capital from loans for which the supply contract and liability agreement form the security. Working capital is afterwards obtained by building up reserves and retaining part of the sale price.

Danish societies have also avoided some of the mistakes which have so often ruined societies in this country. Suppliers are not paid the full market value at the time of delivery, but a payment in advance is made, the remainder being distributed at the end of the season, when the results of the pool have been ascertained. Members now realise the advantage of such methods and their enlightened outlook on co-operative business problems generally, together with sound management under democratic control, is largely responsible for the success of the movement.

The same essential principles underly the many forms which co-operative activity have taken in Denmark. The seed, manure, and stock improvement societies have contributed largely to the improvement of agriculture in the country, while the credit associations have " aided greatly in making Denmark a nation of farm proprietors ". J.M.J.

Agricultural Co-operation in South Wales: An economic and financial analysis.

J. Morgan Jones. Published by the Agricultural Economics Department, University College of Wales, Aberystwyth. 1927. 36 pp.

A general survey of the agricultural co-operative movement in South Wales, but in detail mainly concerned with the trade in farm requirements. Total sales of forty-two requisite societies in 1926 amounted to £814,476 and of six produce societies £33,580, a grand total of £848,000. The membership represents some two-thirds of the farmers in the area. In spite of the fall in prices of agricultural requirements, the turnover of societies has increased since 1923. Nearly 80 per cent. of the turnover consists of sales of feeding stuffs, 5 per cent of seeds, 6 per cent. of fertilisers, and 9 per cent. of household and miscellaneous requirements. The " truck load societies " are small and show a tendency to decline. The records of finance and trade of thirty-one storage societies are analysed in detail to show sources of capital, management and trading expenses, profit and loss, proportion of credit trading, and financial operations. Analysis of sources of the capital used shows that 35 per cent. is obtained from external sources, and 65 per cent. belongs to members, of this only 13 per cent. was paid up, 12 per cent. has been issued as bonus shares and 40 per cent. still remains as undistributed profits and

reserves. Grouping by profit and loss, six societies show losses, twelve show profits representing 0·3 per cent., six profits of 1·66 per cent. and seven profits of 3·1 per cent. of sales on the average in each group. The proportions of credit trading, with their influence on buying and selling prices, are shown to be important in the determination of profit and loss. Small societies tend to show high expenses, and to be uneconomical, but their functions have to be considered in relation to local conditions. A growing demand for delivery of goods is indicated and probable effects on organisation suggested. Various conditions of relations between members and societies, and between the societies themselves, are described and discussed.

At present agricultural co-operation in South Wales is less of a movement than a number of independent trading units. Experience in collective action has been disappointing, but fresh efforts are necessary. Societies dealing in farm produce are experiencing considerable difficulty. They are hampered by unreliability in the quantity and quality of supplies, and by the uncertainty of demand from consuming markets. Guaranteed quantities and qualities of supplies will be necessary for the extension of markets. There is scope for development of co-operation in organising credits and the marketing of farm produce. A.W.A.

Co-operative Business in Agricultural Requisites: The Control of Credit.

A. W. Ashby and J. Morgan Jones. Published by the Agricultural Economics Department. 1927. 13 pp.

This is an advisory bulletin. The recommendations are based on a study of the trade credit conditions of agricultural co-operative societies, mainly in Wales, but they apply to most conditions found amongst societies in Great Britain. The problem of debts and their effects on prices and profits is general though not universal amongst requisite societies. Trading and financial conditions are shown for two groups having respectively small and high proportions of credit trading, also over the average of thirty-one societies. Long credit, or high proportions of credit trading, have influences on methods of finance, on systems or conditions of buying, on price fixing, and ultimately on profits. The general method of control is good office organisation and book-keeping; the special methods—price discrimination, granting discount on cash payments, charging interest on debts, non-payment of dividend on purchases. The case for and against each special method is discussed, and necessary safeguards in the use of each are indicated. The general necessity of credit, and the proper proportions of credit trading, with methods of control, can be decided only in relation to local conditions. T.L.

The Agricultural Co-operative Movement in Wales.

A. W. Ashby and J. Morgan Jones. The Year Book of Agricultural Co-operation. Horace Plunkett Foundation. 1928. 24 pp. Reprinted.

The example of Irish farmers gave the stimulus to agricultural co-operation in Wales. The movement has been developing for about twenty-five years. For propaganda and advisory work Wales was organised with England until 1910, when local organisation began to develop. From 1919 there has been autonomous organisation, but central organisation is now weak. Societies are now scattered over most of the

country, but are least important on the east and south-east border. The development of requisite societies has brought a high standard of honesty and service into the trade in farm requirements. There have been many experiments in organisation for produce marketing, with no notable success and some disappointing, even disastrous, failures. Produce marketing has been mostly concerned with milk, milk products and eggs, though attempts to handle meat have been made. Some requisite societies handle produce, but the extent of this trade is not ascertainable. Land-renting societies have been useful.

The requisite societies are small; many have a turnover of less than £20,000 per annum. A tabular analysis of the business of requisite societies in South Wales shows details of organisation. While standards must be variable, it seems that the society's working capital should be turned over seven times, trade capital four times, and total capital three times a year. (Definitions of terms are given). The chief weakness to-day arises from giving long credits. Share contributions of members have been inadequate, but capital resources have been increased by keeping profits in the businesses. The societies having little working capital, employing a large amount of outside capital, and giving long credits, have the highest handling costs and poorest financial results. All societies suffering losses in 1926 had one or more of the following features—undue reliance on external capital, long credit, or slow capital turnover. But the movement lacks co-operative spirit and enthusiasm even more than financial resources and business ability. Propaganda cannot be substituted for sound business, but extension depends on the education of farmers in the principles and practice of co-operation. This will become more urgent when organisation extends more to the marketing of produce. T.L.

Year Books of Agricultural Co-operation in the British Empire, 1927 and 1928.

Horace Plunket Foundation. Pub. by Routledge.

These two publications, taken together, contain studies on the more important post-war developments in agricultural co-operation within the British Empire. An attempt is made each year to publish statistics of societies in all countries of the Empire, but these are so difficult to obtain that in their present form they do not afford the student much material which can be readily utilised.

Agricultural co-operation over such a wide area naturally presents many features, but some classification on broad lines is possible. In New Zealand, Australia and Canada, producers have organised to a very high degree in controlling the marketing of their produce. Co-operative societies of provincial and national scope are engaged in marketing farm produce, not only in the country of origin, but in foreign markets also. It has been realised that local societies cannot be operated successfully unless members agree to contract for the supply of produce to the Society for definite periods. Moreover, local societies, perceiving their weakness while acting independently, have federated and formed a provincial sales organisation to which they bind themselves to sell. Central Sales Agencies on a commodity basis have also been adopted by provincial federations, thus forming the spectacular pools which are now so widely discussed. The essential basis of the structure is a chain of

supply contracts, together with participation by the locals in the control of the central organisation. More and more attention is being devoted by these large scale co-operatives to improvement in quality of produce through standardisation and grading and the maintenance of standards by inspection. Similar objects, together with the advertisement of Dominion produce, are responsible for the establishment of the Overseas Farmers' Co-operative Federation, which may have far-reaching influences on producers in this country. In practically all sections of these countries the State, by passing favourable legislation and granting financial accommodation, has been an active participant in these movements—even to making co-operation compulsory, as in Queensland. The attempt to control shipments of produce into this country from the Antipodes, though ambitious, is an indication of the stabilising policy at which Overseas producers are aiming.

The importance of the State in providing Agricultural Credit in India, Ceylon and South Africa, justifies the separate grouping of these countries. In India and Ceylon, the veritable curse of usury is being successfully combatted by credit societies, which, owing to the character of the population, have to be very closely supervised by the State. In South Africa, where conditions are different, State aid has advanced along normal lines of supplying facilities for the provision of long and short term credit for productive purposes. As elsewhere, growing crops and warehouse receipts are the main basis of short term credit, and the hope is expressed that the expansion of co-operation in marketing will make possible a more widespread use of the Credit Act.

A review of the position in various parts of the British Isles shows that future attention is turned on one point in particular—co-operative marketing. Although Ireland has developed co-operation for butter production, neither local creameries nor farmers in Ireland have co-operated for the sale of their produce. This anomalous position is now being changed in respect of the creameries, for a central body, the Irish Creamery Association, is being formed for marketing the produce of creameries bound to it by a supply contract. In another field, the organisation of rural credit, co-operation has hardly been a success so far, but a marked advance is phophecied with the recent passing of favourable legislation in the Irish Free State.

All the articles dealing with Britain emphasise the wide field for development in marketing. Whereas the requisite side is well developed, especially in Wales, the co-operative marketing of produce is hampered by fundamental conditions in the marketing structure, although possible lines of advance, notably in livestock and small produce, are indicated.

The very important question of the relation of producers' to consumers' co-operation as reviewed by the Stockholm Conference of the International Co-operative Alliance, is discussed separately and the possibilities of international " balancing " on a large scale are visualised.

A world survey of co-operative legislation is given, and the conclusion is drawn that " more and more States, realising the economic and social importance of co-operation, are taking steps to place it on the most favourable legal basis they have power to confer ".

Bibliographies selected from the Co-operative Reference Library are also included. J.M.J.

ECONOMIC THEORY.

A Primer of Agricultural Economics.

SIR HENRY REW. Pub. by John Murray, London. 1927.

This Primer deals with the subjects of land, farm equipment, farm labour, farm management, cost of production, diminishing returns, markets and prices. The treatment is in part historical and comparative; it is always simple and direct. The method inclines to the application of economic principles to agriculture rather than to the investigation of the economic construction and working of the industry. About 200 pages of text are necessarily inadequate to the exhaustive treatment of all the parts of such a comprehensive field, but the book provides for the general reader an attractive introduction to the subject. A.W.A.

Production Economics.

JOHN D. BLACK. Holt & Co., New York. 1927.

A general book on the economics of production, but of importance to students of the economics of agriculture because it contains a new treatment of increasing and diminishing returns. Ch. 11 deals with the principle of diminishing physical outputs, and Ch. 12 with the principles of diminishing and increasing economic inputs. These chapters contain many agricultural illustrations and Ch. 12 deserves study by all students of diminishing returns in agriculture. Ch. 15 deals with " the earth in production " and largely with land as an element in production. The whole book gives its due place to agriculture as one of the chief branches of economic production. A.W.A.

The Economics of Small Holdings.

EDGAR THOMAS. Cambridge University Press. 1927.

A great deal has been written on the economics of small holdings, but previous publications have been mainly concerned with a general treatment of the subject. This little volume is welcomed in that the results are based on a very thorough and painstaking investigation of a large number of small holdings in Carmarthenshire and that the conclusions drawn are substantiated by statistical evidence. The work is divided into three sections. Section I contains a brief introduction dealing with such matters as the arguments for and against small holdings, tentative conclusions and outline of study. Section II is devoted to a general and historic outline of the area studied. The main contribution is contained in Section III, which presents the results of an extensive survey of 262 small holdings and an examination of financial records kept by ninety-three small holders for one year.

From figures quoted from official statistics it is shown that the small farm has apparently always been a constant feature of the agricultural economy of the county, and in 1925 the number of small holdings of one to fifty acres represented 63·5 per cent of the total holdings. Of these 44·4 per cent. are occupied by owner-occupiers and 55·6 per cent. rented. Of 4,087 small holders only 2,182 or 54·1 per cent. were fully engaged on their holdings, the remainder having additional occupations.

The survey data provides much information regarding the acreage of crops, the numbers of the different classes of live stock kept and the labour employed per 100 acres and the general equipment on holdings of different sizes. The figures prove the superiority of the smaller farms in

their stock carrying capacity and in the employment of labour, and emphasise the importance of cattle, pigs and poultry in the economy of the small holding.

The financial results show an excess of receipts over expenses for all the farm groups and that the balance of receipts per acre increases with the size of the farm. When, however, an allowance is made for wages and for produce consumed by the family and for interest on capital only the milk selling holdings show a favourable balance.

The Appendices contain a bibliography and summaries of comparable studies for Denmark, Norway, Sweden and Switzerland. J.P.H.

EFFICIENCY OF LABOUR.

An Investigation of Certain Processes and Conditions on Farms.

W. R. DUNLOP. National Institute of Industrial Psychology. London. 1927.

The first British attempt to apply the methods of investigation of industrial psychology to farming processes. The processes of which time-studies were made were fruit- and hop-picking and milking. The object of the investigation was to demonstrate in a practical and scientific manner that Industrial Psychology can be usefully applied in agriculture. The section on milking would be of interest to managers of large dairy herds in Wales or elsewhere. The results show differences in amount of work output between individual workers, with some of the reasons. From the study of these reasons suggestions can be made for improvements in equipment and method and in organisation. As regards fruit-picking, suggestions were made. It may be said that the results were not necessarily as definite as the quantitative statements indicate for not all of the possible or practicable checks on the results were used.

A.W.A.

MARKETING FARM PRODUCE.

Co-operative Sales Organisation for Livestock.

THEODORE MACKLIN and MARVIN SCHAARS. Bulletin 394, University of Wisconsin, 1927.

Market Movements of Livestock in Ohio.

GEO. F. HENNING. Bulletin 409, Ohio Agricultural Experimental Station, 1927.

A significant development of agricultural co-operation in the U.S.A. is found in the emphasis placed on co-operative marketing almost to the exclusion of organisation for co-operative buying. An important example of marketing organisation is found in the progress made during recent years in co-operative livestock sales organisation. About one half of the livestock produced in Wisconsin is marketed locally through shipping associations and about one fourth of this volume is consigned to co-operative livestock sales agencies in the central markets.

The first phase of co-operative livestock selling consisted of the operations of Local Livestock Shipping Associations. These were loose organisations with little or no capital stock. The next stage came about through the federation of these local societies into larger organisations serving wider areas. After this movement followed the appointment of selling agents representing the federations on all the large Central Livestock Markets.

These federations are formed on co-operative principles and are governed by a board of directors elected annually at a meeting of the members.

The management is separated into four distinct departments:—

1. Administration of local associations.
2. Central office administration at central markets.
3. Yard and sales work administration.
4. Educational field service work.

Some of the merits of livestock sales organisation are stated to be:—

1. Marketing control over a large volume of livestock.
2. Improvement of livestock and greater uniformity.
3. Reduction of marketing costs.
4. Adjustment of marketward movement of livestock to meet market demands—thereby stabilising prices.

These livestock selling organisations have shown good results financially and from the point of view of service to farmers.

Bulletin 409, 1927, Ohio, deals with the general aspects of livestock production and marketing in that State. By means of dot maps the production of the various classes of livestock in different parts of the State is shown. A second section is devoted to the disposition of the livestock produced. Farm requirements of meat are met largely from the home slaughtering of animals. Local butchers still continue to slaughter a part of the meat sold by them, but the practice of buying their meat from local or the large central packers is becoming general, as this can be done more cheaply than buying livestock for local slaughtering.

The extent of the disposal of livestock through terminal markets is given, together with statistics. A proportion of the livestock is consigned direct to the large Central and Corn Belt Packers. In other cases the packers buy livestock locally. A proportion also is disposed of in Canada by direct marketing.

A third section deals with the extent and capacity of the Ohio packing industry, types and breeds of livestock desired by the packers, weights and grading of livestock and the distribution of meat by the packers.

The last section deals with efficiency factors in the packing industry of the State, losses in the packing industry, and the views of some of the packers on feeding. A statistical summary of the livestock industry of the State is appended. T.L.

Methods in Marketing Study.

A. W. STREET. Agricultural Economics Society, Reading. 1927.

The scope and method of research in commodity marketing is outlined in this study. The analysis of statistical data, followed by investigations in the field are defined as the two main avenues of approach.

Attention is first given to the guidance offered by statistics in the location of supplies, their total volume and the seasonal character of their production. An analysis of the sources from which supplies are

derived provides a measure of the strength of foreign competition, and indicates the territorial limits of the problem.

The all important question of prices is next considered and the discussion emphasises the value of statistics in illustrating long period or cyclical price changes, the seasonal changes, the seasonal fluctuations which occur fairly regularly each year, the local price differences, and the price structure as it stands in various stages of distribution.

The conditions of supply and demand as shown by statistics need further study in the actual field of marketing, and strict impartiality is mentioned as a *sine qua non* of useful investigation. The physical and economic factors determining supplies depend largely on such conditions as the economic features of producing areas, the distribution of various qualities, breed and types, and the interrelation of various farming conditions. On the demand side, field work is necessary to the study of the consumers' requirements as regards quality and quantity and variations in the taste of different districts. Without such study it is difficult to adjust production to requirements and direct it along appropriate channels.

The next step is to measure the efficiency of existing machinery in balancing supply and demand and methods of handling produce. The suitability of various systems of grading, standardising and packing, the economy of various means of transport, the number of middlemen and markets, and the relative advantages of individual or co-operative effort are among the vital problems treated under the classification " the functional aspect of marketing ". The monograph concludes by emphasising the importance of developing marketing intelligence in the movement to more orderly marketing. All students of the subject will appreciate the timely guidance contained in this study. J.M.J.

Marketing of Agricultural Produce.

J. E. Boyle. McGraw-Hill Book Co., New York. 1926.

Dealing with the principles of marketing in Part I of this book, the author discusses first the factors which make consumers' demand so variable and complex. This is followed by an analysis of agricultural production from a marketing standpoint where the seasonal character of supply and the variations in quality are emphasised. The explanation and justification of the middleman system is found in the fact that " the supply of food is produced in the wrong place, at the wrong time, and in the wrong quantity and of the wrong quality " (p. 87).

The author proceeds to examine the problems of transport and storage which arise from the need of creating " place " and " time " utilities. The marketing process is facilitated by the development of marketing credit, which in turn is largely dependent on the extension of the use of standardised grades. Risk-bearing is regarded as a service which must be paid for, but its cost is reduced by the development of news services and trading in futures. The wider use of grades, enabling more goods to be sold by brand, will tend to reduce the cost of distributing farm products. Greater economy can be secured generally by directing production and marketing so that consumers' demand is met both as regards quality and quantity, all markets being supplied with what they need.

Part II follows out these underlying principles as they apply to each product and in Part III the means and ends of better marketing are discussed.

The writer, while emphasising the limitations of co-operation, recognises its value as a means of improving the standard of produce and introducing a healthier tone into business. The duty of the State is chiefly in the direction of developing market intelligence services while fostering standardisation and maintaining suitable grades through a system of inspection.

A viewpoint on the marketing problem is given by the quotation cited on page 216, " 90% of the marketing problem is solved on the farm ". J.M.J.

Markets and Fairs in England and Wales.

Economic Series 13 and 14. Ministry of Agriculture. 1927. H.M. Stationery Office, London.

The detailed survey made in these reports of the markets for farm produce in England and Wales clearly demonstrates that their efficiency can be greatly increased. The historical survey shows the necessity for reviewing and overhauling market rights and charges, and indicates the advantages of more centralised control of the geographic distribution of markets. The special study of livestock markets reveals far too many cases where efficient selling is impeded by bad location and bad equipment and by the comparative absence of facilities for weighing. The actual process of selling is also rendered unsatisfactory by reason of there being too many small markets resulting in the existence of rings and knockouts. The concluding section and Appendix III of the first report lead to the conclusion that continental markets are much better adapted to meet the needs of to-day than those in this country. Hitherto markets have largely failed to create in their users that confidence which is the basis of economical distribution. J.M.J.

Report on Fruit Marketing in England and Wales.

Economic Series No. 15. Ministry of Agriculture. H.M. Stationery Office, London. 1927.

The salient feature of this report is to point out the urgent needs for reform in marketing methods if home grown fruit is to withstand the competition of foreign produce. The comparative localisation of the industry provides a " bottleneck " which should enable producers to exercise some control over the movement of produce to market. The distribution of home grown fruit is now costly owing to wide variations in quality and supplies. Handling and transport costs would be materially reduced by the evolution of standardised grades, whereas gluts and dearths could be diminished by the wider use of cold storage and preservation. Orderly marketing can only be secured by controlling fruit at the point of production and " transforming marketing from an individual to an area basis ". J.M.J.

Report on Scottish Pig Industry.

Report of Committee, Scottish Agricultural Organisation Society, 1927.

In a review of the growing strength of foreign competition, the Committee indicate three reasons for the weakness of the home producer.

In the first place haphazard breeding is a handicap, and it is recommended that pedigree Large Whites, or a first cross with Middle White alone should be used, as these produce the best carcase with which to meet market demand. Reference is made to the breeding work of Edinburgh University, the proposed recording of sows on Swedish lines, and the hope is expressed that the use of premium White boars under the Board's scheme be extended.

Secondly, improvements in feeding methods are necessary and in this connection the work of the Rowett Institute is looked upon to provide farmers with practical advice on rationing. The importance of establishing a better marketing system is regarded as the third factor in developing the industry. Attention is called to the existence of rings and the duplication of middlemen between breeder and feeder, and between feeder and factory or butcher. The necessity for developing a uniform system of recording market prices is emphasised, and a scheme for establishing a Central Sales Agency is outlined. J.M.J.

Report on the Fluid Milk Market of England and Wales.

R. B. Forrester, M.A., M.Com. Economic Series No. 16. Ministry of Agriculture, London. 1927.

This Report is concerned solely with the fluid milk market, and no attempt is made to discuss the position of manufactured milk products.

The earlier chapters deal with the localisation and variation of supplies, the centres of consumption, and problems relating to assembly and transport, thus forming a suitable foundation for the general subject. The various features of road and rail transport are discussed in some detail.

Considerable stress is laid upon the low consumption of milk in this country, and the relation between consumption and quality is examined. In connection with the position as to legislation Mr. Forrester has put forward certain suggestions that might assist in the distinction between deliberate adulteration and the sale of milk of natural low quality. It is further suggested that a satisfactory system of grading must accept, as its basic standard, ordinary market milk. The positions of the producer, distributor and consumer in relation to the milk market are discussed. A chapter is devoted to the factors determining the price to the producer and to a review of the origin, position and effect of bargaining upon a collective basis. The functions and methods of the different sections of the distributive trade are outlined and variations in consumer's demand are examined with a view to the possibility of increase.

Finally the outlook in the fluid milk market is presented and the main issues are brought together in summary form. The Report is suitably illustrated and contains valuable information in the tables and appendices. R.H.W.

The Farmer and his Market. The Land and Nation League.

Ernest Benn. London. 1927.

Opening with a section on the nature of the marketing problem, this report emphasises the necessity of farmers as business men discarding that individualism which is often their *forte* as producers. The abolition of the farmer's economic isolation involves concerted action in the

establishment of standardised grades, which with the aid of advertisement will enable most farm produce to share the economies in distribution obtained by makers of proprietary articles. Another section of the problem is to avoid successive dearths and gluts both in point of time and between various markets.

Action on the part of farmers has not been forthcoming hitherto to any extent and among the reasons responsible for this have been lack of leadership, the misplaced hopes of fiscal protection, and the insecurity caused by the system of tenure. These factors have been largely responsible for the failures of the past, in all of which the following features have been noticeable. Local societies have suffered from the absence of supply contracts, they have rarely co-ordinated activities with similar societies elsewhere, they have been hampered by lack of credit facilities, and lastly have never controlled a sufficient quantum of the supply to influence markets.

The constructive proposals of the report envisage a market system which will result in produce being placed on the market in such a way that short period price instability will be avoided and its reaching consumers promptly after covering minimum distances. It is recommended that a Central Sales Board, operated by persons expert in the various classes of farm produce, be established. The first duty of this Board would be to study producing in relation to consuming areas for each commodity and then to establish local associations for the handling of produce on a commodity basis. The Central Agency would act in an advisory capacity to the local societies, and by building up a Central Intelligence Service would keep them informed of conditions, prices and supplies all over the country. Other functions, such as the defining of grades and giving these due publicity, would also fall to the Central Board. Local associations—not necessarily co-operative—would be responsible for the collection, grading and sale of produce for members bound to them by a supply contract. They in turn would pass on market intelligence to producers and pay them in advance a proportion of the estimated price at the time of delivery. Emphasis is also placed on the importance of credit in efficient selling and a system whereby productive loans would be granted by societies to farmers on the basis of contracts is outlined. A description of the anticipated working of the scheme is given as regards meat and milk, and the possibilities of country slaughtering and conversion of surplus respectively are discussed. The proposals concentrate on organisation at the producers' end and do not anticipate the extension of producers' control in retail distribution.

A chapter deals with the unsatisfactory position which exists at present in the matter of railway rates, and the whole problem of road and rail transport in relation to home produce is reviewed. The necessity of rendering town markets more efficient is apparent from a summary of conditions in London.

The part to be played by the State is also outlined. State assistance will be necessary for some time in advancing capital on loan to societies. The financial commitments of the State are confined to financing the Central Board from funds placed with the Empire Marketing Board. There is also ample scope for assisting co-operation by passing legislation helpful to its development.

Although a " Party " publication, this report is a sane and useful contribution to the literature on marketing. J.M.J.

The Marketing Attitudes of Minnesota Farmers.

By Carle C. Zimmerman and John D. Black. Technical Bulletin 45, 1926. University of Minnesota. Agricultural Experiment Station.

The aims of this study were to discover the attitudes of the farmers of Minnesota towards marketing problems and particularly towards co-operation, and to explain the differences in attitudes between communities and between individuals in order to determine the significant factors influencing marketing behaviour.

The work is the result of a survey where a sample was selected which was believed to be sufficiently comprehensive to represent the attitudes to be found in the State as a whole. Nine communities were chosen for detailed study and a total of 345 farmers were interviewed.

The data obtained consisted of :—

1. Pertinent information relating to the individual farm business.
2. Farming experience and land tenure history of the farmer.
3. Education, reading habits, social and political history of the farmer.
4. Co-operative experience of farmer and organisations in which he had participated.
5. The attitudes of the farmer regarding certain marketing institutions, and practices and other social and economic phenomena within his experience.
6. The farmer's explanation of his own behaviour on attitudes.
7. The explanation of the farmer's attitudes by a " community adviser ", who had known him personally for a number of years.
8. An analysis of the social problems of marketing for each community by local leaders.

The term " attitude " is defined simply as an opinion or point of view on a subject expressed or defined in response to a direct question.

Attitudes are classified into :—

1. Those arising as a result of actual experience.
2. Those arising where there is no actual experience. Attitudes towards the same phenomenon give a distribution approximating a normal frequency distribution.

Communities as well as individuals vary in attitude towards the same concept. It was found that 35% of the farmers had no attitude with regard to stock *versus* non-stock types of marketing organisations, whereas 100% had definite attitudes towards co-operative selling.

Different types of behaviour were attributed to the same motive, and identical behaviour arose from different motives.

National characteristics, actual experience and business conditions, geographic distance, social distance, extreme wealth or poverty affect attitudes,

Based on the investigation, a number of suggestions are given with reference to co-operative marketing development, also the relation of extension work in marketing to the attitudes of the Minnesota farmers.

T.L.

The Marketing of Farm Produce. Part 2, Milk.

F. J. Prewett. Agricultural Economics Research Institute, Oxford.

The primary fact that is put before the reader is the great adaptability of milk to organised marketing and it is pointed out that most of the organisation lies at present on the distributive and not on the productive side. The several marketing channels open to individual milk producers are discussed. Mr. Prewett holds the opinion that there will be a greater specialisation of function of producer, wholesaler and retailer over the whole country in the near future.

The results of a detailed survey of milk marketing in Oxfordshire are described and it is interesting to note the effects of both local and Metropolitan demand upon the area.

A section is devoted to the organisation of producers and deals with both co-operative dairying and the collective bargaining activities of the N.F.U. Considerable stress is laid upon the necessity for greater stabilisation in production and on the weakness of the position of the producer generally, unless he is prepared to destroy the " conversion of surplus " weapon of the wholesaler. R.H.W.

STATISTICS.

The Agricultural Output of England and Wales.

Ministry of Agriculture and Fisheries. Cmd. 2815. 1927. H.M. Stationery Office, London.

A complete survey of agricultural production in 1925, with comparative data on acreages and numbers of livestock for previous periods. Sizes of holdings, employment and wages, motive power, rent and value of land, capital, and agricultural prices are also dealt with. The report is admirably illustrated by maps and diagrams. The estimated value of farm products (on the farms) in 1925 was £225,330,000. The *average* rent of land was found to be 31s. per acre, the capital value of land £31, while farmers' capital per groups of holdings varied from £11 5s. per acre for arable holdings of over 500 acres to £19 10s. for pasture holdings of less than five acres. A.W.A.

RURAL SOCIOLOGY.

FARM POPULATION.

Farm Population in the United States.

Census Monograph VI. Leon E. Truesdell, Department of Commerce, Washington. 1920.

The U.S.A. Census covers a vast field of facts, wider and more comprehensive than anything available for Great Britain. The agricultural part alone covers for each decennial period a larger and more comprehensive collection of data than all the forms of agricultural statistics issued for this country in any ten-year period. Now here is a volume of 536 pages dealing only with the human population on the farms, of which 176 pages are devoted to text and summary tables and the remainder to general tables of data. With a mixed population much more information is required of the census than with a homogeneous one, yet this does not alone account for the bulk of this volume. The real reason is to be found in the scientific and practical interest of the U.S. public and its leaders in their farm population. Statistics, science, rather than senti-

ment, should supply the foundations for consideration of policies and plans. " When the first census was taken only 3 per cent. of the population lived in places of 8,000 or more inhabitants, but in 1920 nearly 44 per cent. lived in such places. With the rapid urbanisation of the nation, it has become increasingly important to know something about the farm population, which is now less than 30 per cent. of the total ", says G. F. Warren in his introduction. The " something " which is given in the body of the book covers subjects far too wide for mere statement in a summary, but the first twenty pages could be read with interest by anyone interested in the condition of rural populations. The economic background consists of the general industrial, commercial and financial conditions of the country. Steam power took away from the rural population their household industries and made them more closely dependent on agriculture for a living. Then the same power used for transportation encouraged specialisation in agriculture and discouraged the diversified type of farm. The increased use of credit in exchange, and of credit capital, assisted business expansion; farmers have shared benefits to some extent but cannot fully benefit until production and marketing are standardised. Improvements in farm crops, animals and machinery, have increased productivity, and a period is being reached in which the application of mechanical power will be the outstanding feature. The development of modern conveniences for living has brought great changes into the farmers' daily life and increased possibilities of enjoyment. The population—as everywhere—tends to move from the land. There must be a natural overflow unless the land is to become overburdened with people. Low prices for produce indicate that too many people have been engaged in agriculture. American farmers must depend to a greater extent on the home market for importing countries no longer absorb surpluses as readily as in the past. As a result of industrial and agricultural specialisation agriculturists themselves enjoy a higher material standard of living. The decline in the farm population need not be cause of regret. As regards quality of remaining population, rural migration may have varied effects. It may lead away those best or worst fitted for agricultural pursuits, those the country can spare or the enterprising spirits which it needs to retain. It is difficult to measure in exact terms the real wages or incomes (satisfactions) of various classes in town and country, for the country satisfactions differ from those obtainable in towns. One set of satisfactions appeal to one sort of person and the other set appeals to another sort. A " new farming " is tending to appear which may bring working and living conditions in urban and agricultural areas more like each other than they are or have been. The new farm population may no longer live apart, " it must rather itself be a part of one unified organisation in which agriculture, manufacturing and commerce are co-ordinated, with free interchange of people among the different branches of productive effort, according to the needs of the nation as a whole ".

The text of this study provides the best introduction to the study of rural population that is contained in any single volume in English. Its atmosphere of common sense, and sense of social change and development, is attractive; and British students should read it as an antidote to some of the literature to which they have become inured.

A.W.A.

Farm Income and Farm Life: A Symposium on the relation of the social and economic factors in rural progress.

Prepared by a Committee—DWIGHT SANDERSON and others—for the American Country Life Association. University of Chicago Press. 1927.

The subjects dealt with are: the measure of rural progress; the fundamental values in farm life; the goal of economic efficiency in agriculture; farm income and standards of living; the economic aspect of rural health; social welfare and economic efficiency, etc. There are nineteen chapters dealing with different subjects and over thirty authors of papers, including the best known American authorities on the economics of agriculture and the sociology of rural life. The Committee say " it is believed that the report gives a new insight into the essential elements of rural progress ", and their opinion may be endorsed. The treatment varies, through consideration of principles, statement of ideals, examination of concrete conditions, and record of experience, to critical analysis of ideas and organisation. An important contribution to the study of efficiency in farming and of satisfaction in living in farming communities. A.W.A.

Success in Farming: Its Nature and Determination.

A. W. ASHBY and J. PRYSE HOWELL. *Journal of the Surveyors' Institute*, Vol. VI, Part 6, December, 1926.

Success in farming is always a personal matter, and every true study of economic causes of success and failure will take into account the " human factor ". The consequence of economic measurement of success in farming is to turn attention solely upon financial aspects. " Profit " is an incomplete measure of success because it fails to indicate the spending as well as the getting of the money. A good standard of living must be one of the results of true success. The constituents of success in farming are (1) " good farming "; (2) " fair business "; (3) " profits "; (4) " good living ". Standards of judgment of success in farming must be relative to period, locality, and type and size of farm.

Success in Farming.

A. W. ASHBY. Essex County Farmers' Union Year Book. 1927.

An extension of " Success in Farming " by A. W. Ashby and J. Pryse Howell. Commercial farming is a process of using land for producing goods for the maintenance, extension and improvement of life, through exchange and consumption. Production, profits, material and non-material standards of living, have all to be taken into account in judging success. Farmers themselves judge by (1) technical efficiency; (2) neighbourliness; (3) business capacity; (4) use of income. Possibilities of variations in success in one or more items are noted.

A possible score-card for scoring success in farming is indicated. Profit is not necessarily a measure of complete success. It is used because it is obvious and more definite than others.

The importance of neighbourliness, in its agricultural as well as in its social aspect, is emphasised: development of farmers' organisation requires more " working with a team ". Good living is evidence of present but also one of the foundations of future success.

Rural Industries of Wales.

The Rural Industries of England and Wales, Vol. IV, *Wales*. A Survey made on behalf of the Agricultural Economics Research Institute. ANNA M. JONES. Clarendon Press. 1927.

This Survey was made in 1922-23. The subjects treated are: the woollen industry; the woodland industries; osier growing and basketry; rush-mat making; besom making; rope making; tannery; pottery; village workshops—carpenters' and blacksmiths', etc., and handicrafts. The report gives a brief description of each industry with some analysis of economic conditions prevailing at the time of the survey. Wales is not rich in rural industries although the woodlands group includes seven separate crafts, and altogether over twenty distinct trades and crafts are described. Some of these are strictly localised and are not of great economic importance. Decline in the wood industries seems to be the result of scarcity of timber. Basket making and osier growing have been affected by cheap foreign imports. In the leather trade there are possibilities of expansion. The larger woollen mills have suffered reverses but the tiny rural mills have not felt much change. Village workshops show tendency to decline except where a craftsman has made use of machinery and developed a manufacturing trade.

A flourishing craft or industry is socially and educationally useful in a rural community. Some of the crafts are worth preserving for their own sake. Education, advice on tools and machinery, raw materials, designs, are needed. A knowledge of book-keeping and business methods would everywhere be advantageous.

The volume is illustrated and well arranged. It should be of interest to persons concerned with the welfare of the rural community.

A.W.A.

FARM POWER.

Small Power Plant for Farm and Workshop.

Rural Industries Bureau Leaflet No. 26. London. 1927.

No other invention of recent times has been so universally adopted by the general public or has effected a more prodigious change in modern conditions of life than that of the internal combustion engine. Its greatest application seems to have been as an agent of transport. The utility of the small stationary or portable power unit by rural craftsmen and farmers has been less freely recognised, as the latter have in most cases discovered to their cost.

The sources from which energy in the form of rotary mechanical power can be economically obtained are:—

1. *Water Power;* or Waterfall energy, has been exploited from early times where available. Initial capital outlay, however, tends to be higher than with oil or gas engines of similar capacity.

2. *Wind power.* This has also been utilised from remote ages. Its greatest disadvantages lie in the uncertainty and irregularity of the amount of energy available and the great bulk of the apparatus relative to the amount of power obtained. Its modern use is restricted to such work as pumping and generating current for electric lighting and its greatest scope appears to lie in the latter direction. Modern scientifically designed windmills have many unrealised possibilities for small power purposes, particularly on farms.

3. *Steam Power.* Has many disadvantages from the small user's point of view, but offers a good possibility where a cheap and suitable supply of fuel exists. The advantages of steam plants lie in flexibility of control and capacity with regard to speed output and fuel consumption, mechanical simplicity and great sturdiness. A steam plant is not, however, economical for intermittent use.

4. *Electric Power:* This form of energy has many and varied advantages, as it can be used for power and lighting purposes. It involves however, the transformation of other forms of energy into electrical energy accompanied by some loss of power. The sources of this form of power for rural areas are:—

1. Individual generating plants.
2. The existence of a local electricity supply company.

Serious drawbacks to the extensive use of electricity in rural areas appear to be the high transmission costs, and a low demand, and these have not offered a very attractive proposition to the promoters of large generating schemes.

Where small individual plants are installed, the cost of power will depend on the primary source of power used, the size of plant, and power distribution methods.

Taking all the advantages derived from the use of electricity for power purposes in rural areas it is estimated that recourse to it would be worth while as long as the cost does not exceed 7d. per unit.

Internal Combustion Engine: This group of power plants is the most important from the rural power users' view point. All these operate on the same general principle, but may differ according to the kind of fuel used.

1. Gas engines:
   (*a*) Using gas from supply company's main.
   (*b*) Producer or suction gas plants.
2. Oil engines using petrol, paraffin or heavy oil.

The relative efficiency of these classes of plant is discussed at some length, and estimates of running costs are given. Various types of engine in each class are described from a mechanical standpoint in some detail, and relative prices of different types of plants compared. Costs, insurance, depreciation and miscellaneous matters relating to the whole class are dealt with, and the publication contains important practical and economic information to the prospective users of small power plants. T.L.

ELECTRICITY IN AGRICULTURE.

The Applications of Electricity to Agriculture.

Papers by R. Borlase Matthews.

1. *Electro Farming.* A paper read at the meeting of the Electro-technical Section of the Koninklijk van Ingenieurs at Nijmegen, Holland, 21st October, 1921.
2. *The Uses of Electric Power in Agriculture. Journal of the Farmers' Club*, Part III, 1922.
3. *Electro-Farming, or the Application of Electricity to Agriculture. Journal of the Institution of Electrical Engineers*, Vol. 60, No 311, July, 1922.

4. *Electro-Farming, or the Application of Electricity to Agriculture. Proceedings of the South Wales Institute of Engineers*, Vol. 88, No. 8, 1924.
5. *Electricity on the Farm.* Published by the British Electrical Development Association, 1924.
6. *Electric Ploughing.* Paper read before the Institution of Electrical Engineers, October, 1927.

In the above papers Mr. Borlase Matthews deals with the whole problem of the applications of electricity to agriculture, both from the technical engineer's point of view and the farmer's view point, being addicted to both pursuits himself. All these publications are well illustrated and contain a large amount of experimental data obtained from Mr. Matthews' 600 acre farm in Sussex as well as other farms in this country and abroad.

The uses of electricity on farms are classified in each publication on the following general basis:—

1. Uses in the farm buildings:
   (*a*) Electric light.
   (*b*) Food preparation.
   (*c*) Dairy—
      (i) Mechanical.
      (ii) Electric sterilisation of milk by
         (*a*) Electrolytic bath.
         (*b*) Mercury vapour baths.
      (iii) Electric heating of incubators for bacterial tests.
   (*d*) Poultry.
      (i) Lighting of laying houses to increase winter egg production.
      (ii) Electrically heated incubators, hovers, and foster mothers.
      (iii) High tension electrical treatment.
      (iv) Mechanical uses.
   (*e*) General electric power.
2. Uses on the farm land.
   (*a*) Irrigation.
   (*b*) General cultivations and manuring.
   (*c*) Treatment of growing crops. (Electro-culture).
   (*d*) Vehicle.
3. Crop treatment:
   (*a*) Electrical treatments of seed.
   (*b*) Uses of electricity in harvesting crops.
   (*c*) Mechanical uses.
4. Rural Industries.
5. Uses in the farm house.
6. Uses in the office.

Apart from treating the actual uses of electricity on the farm, such questions as different sources of supply, with their cost variations, methods of transmission, and farm distribution, and the various types of motors and installations suitable for farm purposes are discussed. The author maintains that electricity is the form of energy best adapted to

all the varied demands of agriculture and rural industries. The two deterrents to its use at present being the apathy of farmers towards its possibilities, and the resulting low demand which will not attract the attention of large industrial stations, together with the difficulty of obtaining suitable motors and equipment specially designed for farm purposes. These latter defects, according to the paper delivered in 1927, are being rapidly overcome. Paper Number 4 is specially concerned with electric ploughing, its advantages, difficulties and cost, using different methods, compared with horse and tractor ploughing costs.

Each publication includes discussions by members of the various Institutions to which they were presented. T.L.

Report on Electricity in Rural Areas.

DOUGLAS NEWTON and M. MANNINGHAM-BULLER. London. 1927.

This memorandum, based on an investigation carried out in Sweden by the writers, furnishes in broad outline a survey of the recent rapid developments in the use of electricity in rural areas in that country.

The main stimulus to Swedish progress arose from the result of a severe coal shortage during the war period, and the war-time prosperity of farmers. Sweden uses its abundant resources of water power for generating purposes, whereas England uses coal, but there is little difference between the two countries in generating costs. It is not the cost of production of energy which governs the price to the consumer but the system and method of distribution with the resulting cost.

The removal of official restrictions affecting transmission methods in England, and the adoption of cheap distribution systems similar to those existing in Sweden, are recommended for rural areas.

A brief account is given of Swedish methods, and of the extent to which farmers in that country use electricity. The latter have formed Local Associations for electrical development which have played an important part in rural electrification.

Factors in Swedish progress are stated to be :—

The formation of Local Farmers' Associations.

Cheap loans.

Less restrictive regulations than is the case in England.

The use of simpler and cheaper materials for distribution purposes.

Uniform schedules of payments for way-leaves.

Educational campaigns.

A wider range of variations in pressure.

Rural enterprise.

A series of recommendations based on the investigation are appended in the hope that they may be of some use in facilitating the electrification of rural England.

T.L.

The Use of Artificial Light to increase Winter Egg Production.

By J. E. DOUGHERTY, Agricultural Experiment Station, College of Agriculture, University of California.

The purpose of the artificial lighting of poultry houses is to increase the winter egg production when supplies are low and prices high.

The aim is to provide by means of artificial light a fourteen hour feeding and exercising period each day during the winter months.

The value of artificial light. Experiments conducted at the California and other stations have shown that winter production can be increased 50% to 60% by artificial light. Hens respond to such lighting within seven to ten days, the full effect being obtained in about three weeks. The annual production per bird is not increased.

The effect of artificial lighting on pullets and hens has not proved in the least injurious, but the consensus of opinion among breeders is that on the whole artificial light should not be used for breeding flocks.

Source of light: All types of lighting methods were tested, but electricity proved the most convenient and least dangerous.

Amount of light: Sufficient light should be provided to amply illuminate the feeding hoppers and scratching floor, and reflectors prove of great value.

One 25 watt lamp, with a suitable reflector, should be sufficient for 60 sq. ft. of ground space.

When to use lights: Under American conditions no benefits were derived from using light before October 1st, or after March 1st. Similar results would probably be obtained in this country. Methods of installing electric lights, and simple types of time switches are shown, and the importance of the proper feeding and care of birds subject to artificial light treatment is stressed. T.L.

ANIMAL NUTRITION.

Abstractor:

R. O. DAVIES, M.Sc., University College, Aberystwyth.

Accessory Foodstuffs for use with Cereals in Pig Feeding.

CHARLES CROWTHER. *J. Ministry Agr.*, 1927, 34, 706-720.

The best supplement to the cereal ration is milk, either as such or in the form of the liquid dairy by-products. For the pig feeder who is unable to command supplies of milk or milk products, a choice of various feeding meals is available which when blended in quite small proportions, usually about 10 per cent., with cereal meals will produce results not far short of those obtainable with milk, the somewhat slower rate of growth being usually compensated by lower feeding costs. R.O.D.

Animal Nutrition; The influence of the various mineral constituents on—and the effect of deficiencies and evidence of such in Ceylon.

M. CRAWFORD. *Trop. Agr.* (Ceylon), 68, 272-81 (1927).

Ceylon herbivora are deficient in the development of the skeleton, horns and tusks, in rate of growth, in milk-producing powers, and in rate of reproduction. Imported cattle cannot live on Ceylon pastures for any considerable length of time. Osteoporosis is common in horses except in the Jaffna Peninsula and on Delft Island. Carnivora show no such symptoms in Ceylon. These facts are probably explained by the small content of mineral elements, especially calcium oxide, in Ceylon grasses.

R.O.D.

Blood composition in Cattle; Effect of phosphorus deficient rations on.

L. S. PALMER and C. H. ECKLES. *Proc. Soc. Exptl. Biol. Med.*, 24, 307-9 (1927).

Numerous cattle in Minnesota suffer from a mineral deficiency which causes stunting, osteophagia and other serious metabolic disturbances. The animals feed largely on prairie hay of which the phosphorus

content is often below 0·2% P_2O_5. Bone meal and other forms of phosphate prevent and cure this condition. Experimental animals were fed a prairie hay and oats diet very low in phosphorus but adequate in calcium over a period of seven days. The plasma was abnormally low in phosphorus, the calcium was normal throughout. R.O.D.

Bulk in Animal Feeding.

FRANK PROCTOR and N. C. WRIGHT. *J. of Agri. Sci.*, 1927, 17, 392-406.

Feeding experiments have been carried out to find whether the bulk occupied by foods affects the quantity of food taken. Experiments with pigs indicate that with high swelling foods the volume to which the foods swell on soaking may be a limiting factor in the ingestion of food by pigs of 40 to 80 lb. live weight. R.O.D.

Calcium, Phosphorus and Nitrogen Metabolism of the Young Pig—The Influence of Diets of Fresh and Treated Cows' Milk on the.

MAGEE and HARVEY. *Biochem. Journ.*, XX, No. 4, 1926.

On a diet of cereals and milk the retention of calcium, phosphorus and nitrogen was lower with heated milk than with fresh or sour milk.

The addition of soluble calcium to a ration containing heated milk raised the retention of calcium, phosphorus and nitrogen. It is suggested that heat has a detrimental effect on the nutritive value of milk and that one of the important contributing factors is the reduction in the amount of soluble calcium. R.O.D.

Cattle; The Food Capacity of.

J. ALAN MURRAY. *J. Agric. Sci.*, 1926, 16, 571-583.

The evidence quoted shows that the " food capacity " of steers increases at nearly a uniform rate from birth up to the age of 12 or 14 months, after which it remains approximately constant. It cannot therefore bear any simple relation to the live weight of the animal. The " food capacity " is taken to be the amount of total dry matter consumed when the animal is offered as much as it cares to eat.

In the case of steers the average constant rate of consumption was about 18 lb. of total dry matter per head per day throughout the period from one to four years of age; in the case of milk cows it is probably about twice as great, viz., from 30 to 40 lb.

The food capacity of steers has been much exaggerated by various scientific writers. In Kellner's tables it seems to be implied that the capacity varies as the live weight and that it may be as much as 64 lb. per head per day, i.e., 3½ times as much as was found in the experiments under review. R.O.D.

Cellulose Digestion. The Mechanism in the Ruminant Organism of.

H. E. WOODMAN. *J. Agr. Sci.*, 1927, 17, 333-338.

Any theory to explain the breakdown of cellulose in the ruminant tract must be compatible with the experimentally demonstrated fact that the products of such digestion of a given weight of digestible fibre are equal in nutritive value to the products derived from the digestion of the same weight of starch. It is shown that in the destructive fermentation of cellulose the initial change brought about by bacteria is hydrolytic in character, resulting in the transformation of the cellulose

complex into sugars. A striking similarity therefore exists between the mode of digestion of starch by enzymes and that of digestion of cellulose by bacteria. R.O.D.

Dietary factors influencing Calcium Assimilation. X. The influence of Ultra-violet light upon Calcium and Phosphorus Metabolism in Milking Cows.

E. B. HART, H. STEENBOCK and H. SCOTT. *J. Biol. Chem.*, 73, 59-68 (1927).

Ultra violet light has little if any direct influence upon the calcium and phosphorus metabolism of dairy cows or upon the calcium and phosphorus content of the milk secreted and is without influence upon the milk production. It is suggested that the cow derives its antirachitic vitamin from the feed and is different in this respect from man, the goat, the chicken, and probably the rat, all of which can be favourably influenced directly by light of short wave lengths. The results should not be interpreted as indicating that exposure of the dairy cow to sunlight is not beneficial. R.O.D.

Fattening Lambs; The Salt consumption of Sheep.

EVVARD and others. *Iowa Sta. Res. Bull.*, 94, 1926.

A study has been made of the relation of the ration to salt consumption and the normal salt requirements of fattening lambs, and is based on the results of seven winters' lamb feeding experiments conducted on thirty-one different rations and 1,306 lambs. In all the experiments salt was self-fed.

Fattening lambs consume much more salt per unit weight than steers fed under similar conditions, and whereas the daily salt consumption of lambs increases during the feeding period, that of steers decreases. Lambs in the finishing lots consume more roughage in proportion to concentrates than do steers; this ratio of roughage to concentrates is the more marked as the period of feeding progresses. The greater the proportion of roughage, the larger apparently is the salt consumption. R.O.D.

Flaked Maize; The Composition of.

H. E. WOODMAN and J. STEWART. *J. Agric. Sci.*, 1927, 17, 60-61.

Flaked maize is produced on the industrial scale by the steaming and rolling of maize grain, and its high digestibility and feeding value for pigs have been amply demonstrated. Figures are given showing that flaked maize as made by the different manufacturers at the present time is a reasonably uniform product, and that the differences between the composition of raw and flaked maize are only the very minor ones that are unavoidably incidental to the processes of steaming and rolling.

The moisture content of the different brands examined displayed considerable variation, ranging from 6·61 to 14·43 per cent. R.O.D.

Hops; The Nutritive Value of Dried Spent.

W. L. DAVIES and R. S. SULLIVAN. *J. Agric. Sci.*, 1927, 17, 380-387.

Dried spent hops possess a high absorptive capacity, and attention is drawn to its use as a " filler " to absorb such by-products as molasses and treacle.

The spent hops were not readily eaten by sheep, and could only be included in a ration in an amount equal to one-seventh of the dry weight

of the total ration. Its digestibility is low. Spent hops included in the ration had the property of depressing the digestibility of the mineral constituents of the basal ration. R.O.D.

Mineral Deficiency; The effect of—on the Yield and Composition of Cows' Milk.

BECKER, ECKYES and PALMER. *J. Dairy Sci.*, X, No. 2, 1927.

Data are presented in connection with an investigation on a deficiency in the rations of dairy cattle common in parts of Minnesota. The symptoms are those of osteomalacia, lack of thrift, low condition of flesh, undersize, abnormal decline in milk production, stiffness in joints, and an abnormal appetite evidenced by persistent chewing of bones, eating wood and dirt. This condition has been shown to be due to a lack of phosphorus in the forage reflected by the small content of phosphorus in the soil. A supplement of calcium carbonate had no effect on the condition of the animals, but a marked improvement and complete recovery from any visible symptoms of osteomalacia was effected when the ration was supplemented with either mono-basic sodium phosphate or tri-calcium phosphate. The data indicate that a shortage of phosphorus in the ration extending over a long period of time may become a limiting factor in milk production, but that under conditions of severe osteomalacia the calcium and phosphorus content of the milk remains normal in amount and in proportion, and there was no indication that the addition of the mineral supplements increased the calcium or phosphorus content of the milk.

Minimum Mineral Requirements in Cattle.

A. THEILER, H. H. GREEN and P. J. DU TOIT. *J. Agric. Sci.*, 1927, 17, 291-314.

Records are given of year old cattle reared to adult weight on rations of varying content in respect of calcium, phosphorus, sodium, potassium and chlorine. There is no good reason to suppose that excess of basic over acidic constituents is necessary in a dietary, and cattle can grow normally to full adult weight, when the usual alkaline reaction of the urine is shifted to the acid side.

Aphosphorosis, or clinically recognisable phosphorus deficiency disease, is experimentally produced, and shown to be identical with the naturally occurring South African disease *Styfsiekte*.

The chemical composition of the milk of animals suffering from aphosphorosis need not necessarily be abnormal, but the inorganic phosphorus fraction of the blood may drop to a quarter of the normal value even before the disease can be diagnosed clinically. Other phosphorus compounds of the blood remain normally high. Blood calicum remains practically normal.

Vitamin deficiency of the diets had no adverse effect. Exogenous requirements of cattle for vitamines A, B and C are so low that they are covered by a few pounds of poor quality roughage, and therefore do not enter into consideration under any natural system of cattle rearing. R.O.D.

Nutritive Requirements of Poultry.

J. B. ORR and others. *Scottish Journ. of Agri.*, 1926, 9, 392-395.

The addition of milk to a cereal ration fed to chickens is accompanied by a markedly increased rate of growth.

Separated milk is as valuable for promoting growth in chickens as whole milk.

Chickens, especially during the earlier stages of growth, require a higher proportion of protein and certain mineral salts than are contained in rations composed of cereals and cereal products. In the present state of our knowledge it would seem that the best source of these extra proteins and salts is milk, but beneficial results may also be obtained from the use of other proteins and artificial mineral mixtures.

R.O.D.

Nutritive Value of Swedes.

T. B. Wood. *J. Ministry Agr.*, 1927, 34, 697-705.

The starch equivalents of two widely different samples of swedes have been estimated and shown to be in each case very nearly 63 per cent. of the dry matter, from which it is argued that swedes from different districts only differ in nutritive value in proportion to their dry matter content. R.O.D.

Pasture; Nutritive value of.

H. E. Woodman, D. L. Blunt and J. Stewart. *J. Agri. Sci.*, 1927, 17, 209-263.

Seasonal changes in the botanical and chemical composition observed during 1926 in a pasture on the heavier soil of the University Farm, Cambridge, are included. Data concerning the utilisation of the protein, lime and phosphate constituents of the pasture grass by sheep in digestion trials are summarised and discussed.

The adoption of a system of close grazing, combined with the use of suitable fertilisers to ensure density of herbage and vigour of growth, enables any handicap arising from inferior botanical composition of the pasture to be overcome.

When the diet of animals on closely grazed pasturage requires supplementing, then carbohydrate and not protein concentrates should be employed for this purpose, this procedure being correct not only for fattening animals, but also for dairy animals and young stock.

R.O.D.

Protein requirements of Dairy Cows.

A. E. Perkins. *Ohio Agr. Expt. Sta. Bul.* 389.

Rations containing variable amounts of protein were fed to producing cows. It is concluded from the results that the older feeding standards call for unnecessarily high amounts of protein, that the actual maintenance requirement is less than that prescribed in the standards, and that above this maintenance requirement an amount of digestible protein only slightly greater than the protein content of the milk appears to be adequate. R.O.D.

Silage Making; Losses in.

J. P. Drew, G. T. Pyne. *Dept. of Lands and Agric. Journ. Irish Free State*, 1926-27, 26, 208-214.

In ensiling a mixed crop (average dry matter content about 22·5 per cent.) of beans, peas, oats and vetches about 12 per cent. of the dry matter is lost and about 21 per cent. of the total weight.

In ensiling a grass crop (average dry matter content about 37 per cent) about 6–7 per cent. of the dry matter is lost. The lower loss in this case would appear to be due to the very slight drainage from the silo, owing to the drier condition of the ensiled material. R.O.D.

Silo; Losses in the Tower.

H. E. Woodman and A. Amos. *J. Agric. Sci.*, 1926, 16, 539-550.

An investigation is described in which an attempt was made to measure the losses of dry matter in different types of silage. The evidence affords strong disproof of the statement that the ensilage of green crops cannot be accomplished without large losses of nutrient matter.

The losses during ensilage may be excessive when the silo is filled with very sappy or rain-laden crops, or when a mass of wet material is superimposed on a crop which has been ensiled at a suitable moisture content. For the purpose of making silage of good quality, and at the same time of keeping the losses down to a minimum, the optimum dry matter content of the green crop appears to lie in the region of 26–34 per cent. When the crop at the time of cutting is wetter than is represented by the lower of these figures it is desirable to allow a period of wilting, if weather permits, to enable the crop to attain a moisture content in the neighbourhood of 70 per cent. R.O.D.

ENTOMOLOGY.

Abstractor: J. R. W. Jenkins, M.Sc., University College, Aberystwyth.

Acarine Disease in Hive Bees; Its Cause, Nature and Control.

Rennie. *North of Scotland College of Agriculture Bulletin*, No. 32, 1927.

The bulletin gives a detailed account of Acarine disease in bees, and numerous recommendations for its prevention and cure. A crawler trap to stand in front of the alighting board is described, crawlers leaving the entrance board fall into the trap, which has a removable glass front by means of which it may be cleared. The crawlers should be killed and burnt.

Given a vigorous queen, and an infection of not more than 30 per cent., the following treatment is recommended. It should not be adopted during the honey flow, but should be used before the bees have finally settled down for the winter; during the winter on sunny days when natural flying is observed; and in spring before the honey flow commences. The mixture used consists of *chloropicrin** 1 part, *camphor* 1 part, *methyl salicylate* 12 parts. Five drops should be dropped on some porous material such as pumice stone or birch bark, which should then be placed below the quilt covering, and the hive closed.

A suggestion is made that the attraction of mites to the spiracles of the bee is chemotropic, and that *methyl salicylate* used in the manner described above, and renewed regularly as the odour fades, may serve to mask the chemotropic attraction of the spiracles. J.R.W.J.

*Note.—The abstractor has found it impossible to obtain *chloropicrin* in this country, and has had to get it from Germany. He will be glad to give assistance to anyone wishing to obtain the substance.

Apple Capsid Bug; Experiments on the Control of.

Staniland. *Journal of Pomology*, V, No. 4, 1926.

The author describes experiments carried out with tar distillate washes and late lime-washes as ovicides, and experiments designed to test the efficiency of oil sprays and nicotine soap washes as

contact sprays against the bugs in the spring. The various experiments show that at 8 per cent. and 10 per cent. strengths, certain tar distillate washes exercised considerable ovicidal action. Late lime-washing proved to be useless. Providing the application is suitably timed, the oil sprays and nicotine soap washes gave satisfaction as contact washes against the bugs, and it is considered that a combination of winter spraying with a suitable tar distillate wash, with spring application of a suitable oil spray or a nicotine wash will prove an efficient method of controlling Capsid bug. J.R.W.J.

Glasshouse Insects; On the control of with Calcium Cyanide.

MILES. *Annals of Applied Biology*, XIV, No. 2, May, 1927.

Experiments on glasshouse fumigation with Calcium Cyanide indicate that this material is a satisfactory source of hydrocyanic acid gas and can be used to control a number of the usual pests infesting glasshouse plants. The Tomato Whitefly was effectively controlled with dosages from ¼–¾ oz. per 1,000 cu. ft. according to the conditions prevailing. At least six species of greenhouse aphides were controlled with dosages varying from 1/7th oz. to ½ oz. per 1,000 cu. ft.

Thrips were more difficult to control, apparently only the adults being affected. A series of fumigations with dosages of ½ to 1½ ozs. per 1,000 cu. ft. was found to give satisfactory control. Two instances are cited where continued fumigations with Calcium Cyanide apparently resulted in control of mealy bugs on tomatoes and vines in Guernsey.

J.R.W.J.

Mangold Seedlings; Collembola injuring the leaves of.

DAVIES. *Bulletin of Entomological Research*, Vol. 17, 1926-27.

An account is given of an attack of mangold seedlings by the collembolan *Bourletiella hortensis* at the Rothamsted Experimental Station. The nature of the damage is described and details given of the control measures adopted. The most successful of the latter was mechanical, the essential constituents being an arched box suspended between two bicycle wheels and closed at the back by a piece of sacking, both box and sacking are tarred. The contrivance is pushed over the drills, the collembola are disturbed by a piece of string or wire hanging loosely across the front of the box, and, on jumping, are caught by the tar.

The machine, with certain height adjustments, was also successfully used for flea beetle control. J.R.W.J.

Mites (*Eriophyes ribis*); Observations on the presence of upon Black Currant Bushes manifesting Reversion and Big Bud.

MASSEE. *Annual Report East Malling Research Station*, 1925. March, 1927.

The importance of these observations lies in the fact that with some varieties, chiefly of the Goliath group, spurious big buds occur as a varietal character. These are free from mites, and produce normal foliage and flowers. On the other hand, absence of big bud does not necessarily mean absence of mites, as microscopical examination of all buds from five bushes showing extreme reversion but with one exception

little big bud, proved the presence of mites in apparently normal buds. These observations have an evident bearing on the efficiency of pruning and burning shoots showing big bud as a control measure. J.R.W.J.

Poultry; The use of against pests of Fruit Crops.

ROEBUCK. *Midland Agricultural and Dairy College Bulletin*, No. 16. May, 1927.

The bulletin commences with a general estimation of the value of poultry as pest controllers, following which is an account of the results of experiments to ascertain which insects are acceptable by poultry, and which are rejected. In a general way eggs of insects are too small for fowls to pick out and eat, but some eggs, such as those of the Poplar Hawk Moth, the larger ground beetles, and chafers, were successfully fed to chicks. Apart from insects, the eggs of slugs and snails are readily eaten by fowls, especially the young birds. It was found that the larval stages are most readily eaten, soft bodied and smooth maggots, caterpillars and grubs being most acceptable. The more brightly coloured, and the hairy caterpillars are regarded with suspicion and frequently rejected. Sawfly caterpillars appear to be usually rejected.

As regards the pupal condition, when the pupae are enclosed in a coccoon they do not appear to be acceptable, otherwise they are readily eaten.

The adult insects fall into four classes, moths and butterflies are usually rejected; hard bodied insects, such as beetles, sometimes eaten, but not often; colourless winged insects, such as flies, frequently eaten; and the small insects, such as Midges and Springtails, not touched. There follows a calendar giving the pests which may be reached by poultry in the various months, and the stages and situations in which they occur.

The bulletin concludes with a list of those pests against which some measure of control is obtained by keeping fowls, and a list of those against which no degree of control may be obtained.

J.R.W.J.

Reversion in Black Currants; Experiments in the Transmission of.

AMOS, HATTON, KNIGHT and MASSEE. *Annual Report East Malling Research Station*, 1925. March, 1927.

The first part of this article deals with experiments to determine whether direct infection of normal plants with big bud mites (*Eriophyes ribis*) was followed by the development of the symptoms of reversion. After successful artificial infestation with mites 90 per cent. of the normal black currant bushes developed reversion. No big buds developed and no symptoms of reversion occurred in thirty-five out of forty-three bushes acting as control. Of the remaining eight controls, three showed reversion but no obvious big buds, but the presence on one of these bushes of another mite, *Phyllocoptes masseei*, which does not cause big buds, was a complicating factor which is receiving attention. There is very little relation between the number of visible big buds and the intensity of the accompanying reversion symptoms.

A number of experiments were carried out on the transmission of reversion by other means. Normal bushes were grafted to or inarched with reverted plants, and in every instance the disease was transmitted, with strong but not conclusive evidence that transmission was independent of mites. It was not found possible to produce reversion by sap transfusion and the evidence indicated that reversion is not regularly or easily transmitted by pruning. J.R.W.J.

Root Mealy Bug and Root Aphis; Insecticides for.

SAUNDERS. *Annals of Applied Biology*, XIII, No. 4, Nov. 1926.

A large number of substances were tested for toxity against the root mealy bug which attacks various species of Acacia amongst other plants and against the Lettuce Root Aphis.

A number of substances were found to be completely toxic to the insects and harmless to the plants, and the three following stand out as being the most effective and suitable:—Tetrachlorethane, Trichlorethane, and Potassium sulpho-carbonate. A 1% solution or emulsion as the case may be is used, the method of treatment being to fill the pot to the brim with the liquid as in the ordinary method of watering pot plants. J.R.W.J.

Screw Worms: Benzine as a Larvicide for.

PARMAN. *Journal of Agricultural Research*, XXXI, No. 9, November, 1925.

The article describes the successful use of commercial benzine as a larvicide for screw worms. It has no ill effects on the wounds, and acts as a styptic temporarily to make the wound less attractive to the adult flies. When used in wounds as a larvicide for the screw worm it has not been found to be toxic to any animal. J.R.W.J.

(The interest of the article lies in the fact that the Screw Worm Fly is closely related to, and causes damage similar to that caused by our Sheep Maggot Fly, and it is probable that Benzine treatment would prove satisfactory against the latter pest).

Soil Insects and their Treatment; Some.

THEOBAL. *South Eastern Agricultural College, Research and Advisory Department, Bulletin* 5, January, 1927.

The Bulletin gives a popular account of the chief soil pests and of the methods used for their control. Among the pests dealt with are leatherjackets, cutworms, wireworms and chafer grubs. J.R.W.J.

Wireworms; Investigations on the control of.

MILES and PETHERBRIDGE. *Annals of Applied Biology*, XIV, No. 3. August, 1927.

The first part of the article is devoted to a survey of the wireworm problem. It deals with the historical aspect, the feeding habits of wireworms in relation to weeds, the seasonal movements of wireworms in the soil, and gives observations on wireworm attacks.

The second part gives an account of baiting experiments, which indicate that large numbers will collect to baits such as wheat, oats,

and bran, and moreover these baits can be used to attract wireworms from the roots of crop plants on which they are feeding. An account then follows on experiments combining baiting and fumigation with granular calcium cyanide, these shewed that the cyanide used in connection with the baiting, at the rate of 2-3 lb. per 100 yd. of bait row destroyed 70-100 per cent. of the wireworms assembled. J.R.W.J.

FORESTRY.

How a Tree Grows.

SIR WILLIAM SOMERVILLE, K.B.E., M.A., D.Sc., LL.D. Clarendon Press. 1927. Price 10s. net.

This little volume of 242 pages is " the expansion of some notes of lectures given to Forestry Undergraduates in Oxford ". It is a moderately elementary treatise and as such can be read with interest and profit without a wide acquaintance with Botanical Science. Nevertheless the author has brought together much information which either is not to be found or is not readily available in general textbooks of botany and he has added another great service to the many conspicuous ones previously rendered by him to British students of Forestry and Forest Botany. As he himself points out, he has occasionally deviated from strict adherence to the theme suggested by the title of the book. As the chief example of this one may mention the inclusion of a section dealing with the identification and uses of timbers. This addition simply increases the value of the volume. The text is illustrated by exquisite drawings by Miss Helen Bancroft, D.Sc., School of Rural Economy, Oxford. W.S.J.

GENERAL.

The Ministry of Agriculture and Fisheries.

By SIR FRANCIS L. C. FLOUD. (The Whitehall Series). pp. x, 330. (London and New York: G. P. Putnam's Sons, 1927). 7s. 6d. net.

This book is one of the Whitehall Series of volumes which are intended to give the public an account of the history, organisation and work of the various Departments responsible for carrying on the administrative business of the country, and has as its subject the Department, which above all others, is of most direct interest to agriculturists, viz., the Ministry of Agriculture and Fisheries. It has been prepared by Sir Francis Floud, who until recently was Permanent Secretary to the Ministry and who, owing to his long association with the Department, had exceptional qualifications for undertaking the task. His own personal distinction and the esteem in which, by his sympathy and judgment, he was, and is, held by his colleagues as well as by the many of the farming public who had the opportunity of coming into contact with him, give to this volume a value and an interest that scarcely could have been given to it by anyone else. The book gives in nineteen chapters a lucid account of the history of the Ministry and of its functions and in sufficient detail to enable the reader who is not familiar with the

machinery of a Government Department an admirable idea of how it works, while to those who already possess a general knowledge of the working of an elaborately organised office, it gives an equally admirable idea of how this particular Government Department is designed and organised to deal with the work that is especially its own.

While, as the author observes, agriculture and fishing are the two oldest industries of the human race, the Ministry of Agriculture and Fisheries is, with one exception, the youngest of the Departments of State which are represented in the Cabinet. The Department came into existence in 1889 and in its present reconstituted form in 1919. But though historically the industries which give its title to the Department were not represented in the Cabinet until recent years, they are now, as the author further observes, the only industries that have a Cabinet Minister of their own to represent them in the Government. In this and in other ways, the Ministry of Agriculture and Fisheries differs in conception and in function from other Departments of State.

The functions of the Ministry are extremely varied, involving work which covers a very wide field. It has to be borne in mind that it is the Ministry's business not merely to administer Acts of Parliament relating to the industries concerned but also " to suggest and initiate schemes which will assist in the development of agriculture and fisheries in the national interest ". The book before us shows clearly and precisely how all the varied activities of the Department are directed and controlled; how the different divisions responsible for particular sections of the work are co-ordinated; and describes fully the relation between the Ministry and the Local Authorities in the carrying out of functions with which they are jointly concerned. Of particular interest to readers of this *Journal* are the chapters dealing with Agricultural Education and Research, with Live Stock Improvement, and with the more recent work of the Ministry in connection with the economic side of agriculture. The special chapter contributed by the Fisheries Secretary contains much information of interest to those concerned with the fishing industry as such and serves, at the same time, with much more in the book, to bring home to the general reader the multiplicity of the Ministry's functions and the many points at which it touches the life of the community.

Even amongst agriculturists for whom the Ministry primarily exists as a Department of State, there is often want of knowledge as to the functions of the Ministry and especially as to its powers. There is not infrequently, in consequence, misunderstanding as to its procedure and methods. Nothing could be more helpful than this book in providing the information that is necessary to enable the reader to understand what the position of the Ministry is in regard to all these matters and in showing how it is equipped for dealing efficiently with the business entrusted to it. Since the Department was established in 1889, there has been a striking expansion in the scope of its work, both technically and administratively, and its organisation is such that this expansion has been accompanied by increasing efficiency. Sir Francis Floud's book is in itself an example of the spirit which animates the Ministry and is in every way an admirable presentation of the methods and objects of what the author in his dedication describes as " the most human of all Departments ".

C.B.J.

GRASSLAND.

Abstractor:
R. Alun Roberts, Ph.D., University College, Bangor.

Grassland; Its Management and Improvement.

R. G. Stapledon and J. A. Hanley. Oxford: The Clarendon Press. 1927. 159 pp. 5/- net.

Many shrewd judges of stock and most farm crops lack appreciation of real quality in their grass and pastures. The main reason for this is the technical difficulty of recognising the elements contributing to the sward, particularly when it is closely grazed. While it cannot be claimed that a perusal of this book, or of any other for that matter, can obviate this initial difficulty, it can however be said at once that serious thought over this volume will quicken the faculties of the intelligent reader and give him a coherent and unified picture of the considerations involved in forming a critical estimate of a grass field. The problems dealt with are immediately urgent over all the country in view of the current decline of arable cultivation generally, but they are of special importance because they are ever present in a more or less acute form in Wales, essentially and necessarily, for the most part, a grass country.

The subject matter is divided into fourteen chapters, followed by an extensive bibliography of relevant publications and original papers. Chapters I and II, dealing respectively with natural and semi-natural types of British grasslands, may seem sketchy judged by the Ecologist. Yet one fails to see how they could have been extended having regard to the limitations of space and the practical agricultural aspect that is maintained throughout. The interested Welsh reader should follow up this section with Professor Stapledon's earlier Aberystwyth publications so admirable in their treatment of the vegetation types of the sheep walks of Mid-Wales and the improvement of hill pastures generally. Chapters III and IV, dealing with fundamental considerations of improvement and the mechanical treatment of grassland, are worthy of special commendation. No indictment of the decline in attention to mechanical treatment of outrun pastures in the hill districts of Wales during the last generation can be too severe, and it should be stressed that over most areas this is the key factor in improvement and the first move towards amelioration. Chapters V to IX, dealing with liming, manuring, the influence of the grazing animal, and renovating without ploughing, will then follow logically for their due consideration and respective application. The authors' extensive knowledge, gleaned over a broad area, renders these sections very wide in their application. It is in the nature of things that Chapter VII on the manuring of mowing land is the least applicable to Welsh conditions, but Chapters X and XI on the ploughing and immediate reseeding of derelict grass and the significance of temporary leys should be singled out for earnest consideration by the discerning Welsh farmer. There is no conviction that grows on any one habitually associated with grassland problems in Wales more than the calamitous frequency with which leys that have obviously long since outspent their economic usefulness are allowed to remain in grass.

Chapter XII is given to a brief appreciation of the merits of the most important herbage plants and the rest of the book deals summarily

but effectively with seeds mixtures and establishment. Here again one feels the farmer has much to learn. Though we have advanced far in practice within the last generation, when we recollect the old practice of seeding with hay loft seed, much economy remains to be effected by a judicious use of seeds mixtures discreetly selected. The pith of the matter is given us here.

One can foresee the need for an early second edition of this book; firstly, we would hope, from the exhaustion of the publisher's present stocks, and secondly, because a few more seasons will find the editors eager to incorporate new information on matters such as the mineral content of pastures and its correlation with the physiological welfare of the grazing animal, the significance of controlled grazing and the newer ideas on nitrogenous manuring. These aspects have not been overlooked in this edition, but as they are only now being critically pursued, any fuller pronouncement on them at the present moment could only be regarded as premature. R.A.R.

LIVE STOCK.

Abstractors:

J. A. Fraser Roberts, M.A., B.Sc., F.R.S.E., University of Edinburgh, and University College, Bangor; and A. D. Buchanan Smith, M.A., M.S.A., B.Sc., University of Edinburgh.

Animals; Abnormal Sexuality in.

F. A. E. Crew.

I. Genotypical. *Quart. Rev. Biol.*, Vol. I, pp. 315-359, 1926.
II. Physiological. *Ibid.*, Vol. II, pp. 249-266, 1927.
III. Sex-reversal. *Ibid.*, Vol. II, pp. 427-441, 1927.

Problems of abnormal sexuality have received much attention recently and great activity prevails in that field. This series of three papers present a thoroughly systematised and exhaustive review and will be of great assistance to research workers on physiology and genetics. J.A.F.R.

Cattle; Night Blindness in.

W. A. Craft. 1927. *J. Hered.*, Vol. 18, pp. 215-216.

In a herd of Dairy Shorthorns in Oklahoma the behaviour of the animals suggested that they were blind at night, while in sunlight they appeared to have a normal vision. No visible eye defect could be seen. Examination of the pedigrees of the affected calves showed that they were related and showed line breeding to a common ancestor. The data available were insufficient to define the mode of inheritance, but it may be taken to be, in general, recessive. A.D.B.S.

Cattle; The Inheritance of Horns in.—Some further data.

A. D. Buchanan Smith. *J. Genet.*, Vol. 18, pp. 367-374, 1927.

The normal mode of inheritance of horns in cattle is for the polled condition to be dominant, i.e., the mating of two horned beasts will never throw a polled one, and also a purebred (homozygous) polled animal, e.g., Aberdeen-Angus mated to a horned one, e.g., Shorthorn, will produce only polled calves. In this paper are noted some apparent

exceptions to the established rule. A cross of Aberdeen-Angus on native cows of Northern Rhodesia produces polled heifer and horned bull calves. In this case the inheritance of horns appears to be conditioned by sex. Exceptions in crosses involving the White Park cattle of Great Britain are also noted. In the discussion it is pointed out that in an early form of cattle the males appeared horned and the females polled. It is interesting to speculate whether because the crosses involved were made with cattle not of the domesticated breeds that there was therefore a harking back to the primitive type. The purpose of this paper is to show that there appear to be factors which modify the normal mode of inheritance. A.D.B.S.

Characters "Capacity for Fat Production"; The Inheritance and Transmission of the.

C. W. Turner. 1926. *Missouri Agr. Exp. Sta. Bull.*, No. 236, p. 49.

A study of the progeny performance of 263 Guernsey sires having nineteen or more daughters has been completed.

The yearly butter fat records of the daughters and their dams were converted to their " mature equivalent " production, so that comparisons could be made on an equitable basis. By grouping the sires into classes on the basis of the daughters' average yearly fat production and then determining the quality of the daughters out of dams of various productivity, it was found that for each 100 pounds of fat per year increase in the production of the dams there was a corresponding increase in the production of the daughters of approximately 15 pounds of fat.

The results were expressed in the form of equations as follows:—

(1) Daughter's fat production =

$$0{\cdot}15 \times \text{Dam's fat production} + 0{\cdot}85 \times \text{Sire's potential transmitting ability.}$$

(2) Sire's potential transmitting ability =

$$\frac{\text{Daughter's fat production} - 0{\cdot}15 \times \text{Dam's fat production}}{0{\cdot}85}$$

By means of genealogy charts, the ability of the sires and dams to transmit the favourable factors concerned in fat production through their sons to the grand-daughters was studied. It was found that sires were more able to transmit their potential production through their sons to their grand-daughters than were the dams able to transmit *their own production* (as indicated by their best converted fat record) through their sons to their grand-daughters. A.D.B.S.

Climate; Relation of Sheep to.

E. L. Johnston. *J. Agr. Res.*, Vol. 29, pp. 491-500, 1924.

A study of the temperature, rainfall, and relative humidity of important sheep producing areas indicated that sheep are limited to certain climatic conditions, dense centres of distribution occurring within comparatively narrow limits of these climatic factors. Critical periods occur at lambing time, in the rutting season, and during gestation; bad sheep years have unfavourable conditions in one of the critical periods. Mild winters, cool summers and sufficient rainfall for the production of good grazing constitute the optimum conditions. The growth of lambs is retarded by high temperature and humidity, also by excessive rainfall and cold weather. The rutting season comes with falling

temperature and varies from year to year; if the critical periods are greatly disturbed, sheep are not likely to be numerous or profitable. While the limits of successful sheep production can be extended by proper methods of housing, the author is of the opinion that more attention should be given to finding breeds best suited to particular localities. J.A.F.R.

Corriedale Sheep in Great Britain.

J. E. Nichols. *J. Ministry Agr.*, Vol. 34, pp. 246-251, 1927.

As is well known, the Corriedale is a breed of some 25 years' standing, having been evolved in New Zealand from crosses between Merinos and Longwools, mainly the Lincoln. The ideal was a sheep with a heavy fleece, and a useful fat lamb.

The sheep described were imported into Scotland and the flock which at first consisted of some twelve rams and twenty-three ewes were kept under precisely the same conditions as the rest of the flocks on the farm. The lambs are born with a kempy protective coat, which is rapidly shed, leaving the desired uniform fleece. The wool of the adult has not been thoroughly examined, but appears to average about 9 lbs and is of good quality. When shorn, the sheep are seen to be of good mutton type.

In crosses with other breeds, Cheviot, Halfbred, Dorset Horn and Crossbred, lambs have been examined at the age of 6-8 weeks. They were all of good mutton type, the Dorset Horn crosses looking particularly well in this respect. In the Cheviot cross there are distinct traces of the neck folds, and compared with the Halfbred cross the latter have a more uniform coat with fine wool down the legs and a more typical Corriedale crimp. J.A.F.R.

Cows; Sterility in.

W. Frei, of Zurich, and A. Staheli. *Deut. Tierarzt. Wochens.*, Vol. 34, Jan., 1927.

The authors examined some 1,809 cases of sterility. Of these, 183 cases (7·3 per cent.) were due to the failure of cows to come in season. Of these 133 cases, eighty-seven (65·4 per cent.) were found to be due to the persistence of the corpus luteum; ten cases (7·5 per cent.) were due to ovarian cysts, and thirty-six cases (27 per cent.) to other ovarian abnormalities. The writers are inclined to doubt that the persistence of the corpus luteum is always due to endometritis (inflammation).

The cysts could be regarded as the cause of the failure to come in season of the cows possessing them. They inhibit the ripening of follicles. The removal of the cyst was followed by heat in seven cases out of ten, though only four became pregnant. In the other cases endometritis probably prevented conception. Regarding these cases, where the cause could not be attributed to the retention of the corpus luteum or to cysts, the ovaries were either inactive or atrophied. Treatment such as massage, injection of ovarian hormone and the implantation of normal ovaries proved successful in the large majority of cases.

As regards extra-genital causes (i.e., nutrition, husbandry, milk-yield, etc.), it was found that the non-occurrence of heat was more frequent in younger than older cows, though the evidence on this point is not critical; but it may be connected with increased lactation in

younger animals. The treatment mentioned above proved of use in many of these cases. A.D.B.S.

Crossing between Yak (*Phoephagus grunniens L.*) and Zebu (*Bos Indicus*).

M. M. Zavadovskii. *Trans. Lab. Expt. Biol. Zoo-park,* Moscow. 1 (1926), No. 1, pp. 245-251.

A brief account is given of the offspring produced by crossing a zebu bull with a yak cow in the Zoological Park at Moscow. Seven offspring were produced as the result of back-crossing the zebu bull to his cross-bred daughter. It is pointed out that the offspring are fertile, at least as far as females are concerned. The inheritance is alternative, and segregation is clearly observed in the pigmentation of the hair, the length of the hair, and the hump. J.A.F.R.

Dark Fibres in the Suffolk Sheep; On the occurence of—with particular reference to the birth coat of the Lamb.

J. E. Nichols. *J. Text Inst.,* Vol. 18, pp. 395-414, 1927.

This paper presents a very complete study of colour and colour changes in the Suffolk breed and raises many important questions relating to the development of pigment in general in the mammalian coat. Data are presented on the colour changes from birth to maturity of the face, head tuft, and general body areas, and on the variations in the amount of dark fibres in the fleece of the adult. It is concluded that the change in the gross colouration of the head tuft from birth to maturity is probably the best indication of the ultimate amount of dark fibre in the adult fleece. This can be supplemented by observation of the body colour at about 50 and 100 days. An interesting hypothesis is advanced to explain the complicated changes in pigmentation that occur and it is suggested that temperature may play some part in the development of pigment as it does in the " reaction of Schultz " in the Himalayan rabbit. J.A.F.R.

Determination of the Fineness of Wool and of the Fleece; A new method for the.

J. A. F. Roberts. *J. Text. Inst.,* Vol. 18, pp. 48-54, 1927.

Previous methods for measuring the sample fineness of wool have almost invariably been dependent on the magnification of the fibres or their direct measurement with calipers. The new method suggested is that sample fineness should be estimated by determining the number of centimetres of fibre that weigh a milligram. This method appears to possess advantages over others on the score of accuracy and convenience and also provides the required information in a simple and useful form. J.A.F.R.

Development of the Clydesdale Breed of Horses; The Rôle of Inbreeding in the.

A. Calder. *Proc. Roy. Soc. Edin.,* Vol. 47, pp. 118-140, 1927.

The writer uses Sewall Wright's co-efficient of inbreeding. In the early history of the breed there is little indication of inbreeding, the first marked rise in the average amount occurring during the period 1860-1890. From that time onwards there has been a gradual and constant increase up to 6·25 per cent. during the period 1920-1925.

The sire Darnley made the greatest contribution to the average percentage of inbreeding until about 1912 and since that time the chief contribution has been made by Baron's Pride. There has been more inbreeding to Baron's Pride than to any other sire. With the exception of Prince of Wales there has been no appreciable inbreeding to any sire outside the line of descent from Darnley. It is shown that the average percentage of inbreeding for mares rises above that for stallions during the periods 1885-1890 and 1890-1895 owing to the fact that during those years the average inbreeding to Prince of Wales was much higher for mares than for stallions. The average for the two sexes is most nearly equal at the periods when the most marked rise occurs in the breed as a whole.

The most popular systems of matings are discussed; cousin to cousin matings are fairly common, while half-brother to half-sister matings, and sire to grand-daughter matings are only practised with animals of the very best breeding.

The increase of homozygosity in the Clydesdale breed due to inbreeding alone is 6·2 per cent. Line breeding, so confined to the one line of descent, and also careful selection have been responsible for a great increase in homozygosity. J.A.F.R.

Domestic Cow (*Bos taurus*); Œstrous Cycle in the.

Effects of Ovarian Extract. (Sixth Report).

H. S. Murphey, G. W. McNutt, B. A. Zupp, and W. A. Aitken. *Anat. Rec.*, Vol. 29, p. 370, 1925.

At the Iowa State College sterile follicular fluid diluted with physiological salt solution was administered intravenously to spayed cows, spayed bitches, pregnant cows, and sterile cows. The results showed that certain indications of heat were produced in the spayed cows and spayed bitches, but this was not complete. Heat was produced in the pregnant cows and coitus accepted. Fifty per cent. of the sterile cows showing no abnormalities or disease became pregnant. Sterile physiological salt solution extracts of corpora lutea of different ages appeared to have no effect on the normal œstrous cycle. J.A.F.R.

Domestic Fowl; On Fertility of the.

F. A. E. Crew. *Proc. Roy. Soc. Edin.*, Vol. 66, pp. 230-233, 1926.

Many interesting observations are recorded, the main conclusions being as follows:—

1. Fertile eggs can be expected within 24-28 hours after the introduction of the male, though the onset of fertility varies with different matings.
2. The length of life of the sperm in the body of the female is about 15-20 days, though in exceptional cases it may be greater.
3. Eggs laid after the first week following removal of the male commonly fail to complete their development.
4. If after removal of the male a second male is introduced, the influence of the first male is removed by the seventh to tenth day, the exact time varying in different cases. There is a relation between the general vigour of the individual and the fertilising power of its sperm. J.A.F.R.

Fertility in the Sheep; Meteorological Factors affecting.

J. E. Nichols. *Zeit. f. indukt. Abst. Vererb.*, Vol. 48, pp. 318-329, 1927.

This paper presents an analysis of data obtained from a Cheviot and a Blackface flock kept together under similar conditions during the period 1911-1924. It is found that there is a significant breed difference in fertility. In the Cheviot variations in fertility are mainly linked up with variations in the amount of barrenness and abortion, while in the Blackface other factors are also involved. There is no significant difference between the two breeds in the mortality among the lambs between the end of the lambing period and the time of castration. There is not sufficient evidence to warrant a conclusion as regards the effect of mean daily temperature and daily range of temperature at tupping time on fertility, but there may be some slight association between high mean temperature and high yield in the Cheviot flock and between high daily range of temperature and low yield in the Blackface flock. Rainfall and number of rainy days at tupping time have no significant effect except that there is some slight suggestion of an association between rainy days and low yield in the Blackface. Mean daily temperature at lambing time is of no importance, but the association between low mean daily range and low yield is significant in both breeds. The most important meteorological condition affecting fertility in both breeds is the number of rainy days at lambing time, probably from its effect on early post-natal mortality.

The writer adds the caution that the results from these two flocks must not be applied too readily to the two breeds in general, as these particular flocks might not be typical in all details of management, etc.

J.A.F.R.

Fleece Fibres of British Breeds of Sheep; Studies on the.

J. S. S. Blyth. *Zeit. Tierz.*, Vol. 7, pp. 383-417, 1926.

This paper describes the results of an extensive histological survey of the wool of various British breeds of sheep. The writer distinguishes two main fibre types, called 1 and 2, and two subsidiary ones, kemp and extremely fine short fibres resembling the finest fibre of type 2, but not always present. Fibres of type 1 are longer and coarser than fibres of type 2, and are to be distinguished from them mainly by difference in scale markings. Fibres of type 1 are found in the lustre and mountain longwool breeds, and fibres of type 2 are the main constituent of the fleeces of the short-woolled breeds, though they also occur in the longwools.

J.A.F.R.

Hernia in Swine; A Study of.

B. L. Warwick, *Wis. Agr. Expt. Sta. Res. Bull.*, No. 69, 1926.

The results of this paper leave no doubt that a rupture is an inherited characteristic. The writer, in selecting pigs for hernia, obtained 7·49 per cent. of cases where the male pigs were ruptured in the original herd, 14·28 in the first generation, 42·0 per cent. in the second, while the third generation had 43·18 per cent. of the males herniated.

The author has tabulated the chief practical considerations which are the outcome of this study. Some of them are as follows:—

1. Never use for breeding purposes a boar which is or ever has been afflicted with inguinal hernia. This includes animals in

which hernia has disappeared naturally, as well as those in which it has been reduced by operation. Whether hernias would appear among the immediate offspring of any such boar would depend upon the hereditary make-up of the females with which he was mated. In any case all of his offspring would carry some of the factors responsible for inguinal hernia.

2. Discard any normal boar which has sired one or more herniated pigs. Such a boar will transmit factors for hernia to more than half his offspring and hence tend to carry it on in the herd, even though the sows to which he is mated should be entirely free from the taint.

3. Do not select breeding stock from sows which have produced one or more inguinally herniated pigs. The same reasons apply here as in the case of the male.

4. Do not retain for breeding purposes litter mates to inguinally herniated boars, especially the males. Some of these will probably be free from the hernia factors, but it would require extensive breeding tests to determine which ones these are.

5. Elimination of all of the progeny of boars which have been known to sire inguinally herniated pigs would also be advised. Probably, in many cases, this would not be practicable.

J.A.F.R.

Improved Landschwein; The Litter Size of.

H. A. Bartram. *Züchtungskunde*, 1 (1926), No. 5, pp. 256-269.

The average sizes of successive litters of sows from the first to the twelfth have been tabulated from herd book records, together with calculations of the standard deviation and probable errors of the mean and standard deviation. The average litter sizes for the first to the twelfth litters consecutively were 8·888 ± 0·071, 9·804 ± 0·088, 10·498 ± 0·115, 11·015 ± 0·134, 11·054 ± 0·161, 11·486 ± 0·202, 11·510 ± 0·250, 11·290 ± 0·316, 10·618 ± 0·355, 11·744 ± 0·511, 10·552 ± 0·487, and 11·667 ± 0·938.

These results, as well as other tabulations for the sows having litters in all groups, show that the sixth and seventh litters were generally the largest. The variability in litter size appeared to increase with age.

A.D.B.S.

Influence of the Age of Parents upon their Offspring; A Contribution toward the Analysis of. The Age of Ewes and the Rate of Growth of their Lambs.

R. Prawocheński and B. Kaczkowski (*Pam. Państ. Inst. Nauk. Gosp. Wiejsk. Pulawach*) (*Mém. Inst. Natl. Polon, Écon. Rurale Pulawy*), 7 (1926), A, pp. 139-157.

Studies of the birth weights and growth of lambs produced by young ewes and old ewes, both of which were mated to the same ram, indicated that the birth weight of the offspring of young ewes was much less than that of older ones, and that the rate of growth of the lambs during suckling was also greater for the lambs produced by the older group. As soon as the lambs began to consume pasture those produced by the younger ones grew more rapidly and soon overtook the lambs produced

by the older ewes. Several breeds of lambs were used in the study, including Southdown, Swinarka czarna, Swinarka biala, Padhalánski, and crossbreeds. J.A.F.R.

Kemp.

J. A. F. ROBERTS. *Bull. of the National Association of Wool Manufacturers (U.S.A.)*, Vol. 57, pp. 354-367, 1927.

A general account of kemp in the fleece and its relation to other fleece fibres and to other characteristics of the sheep. The points dealt with include the origin of kemp, its structure, its growth, its separation, qualitative and quantitative, from other fibres, its relation to the birth coat, to face-hair and to coloured fibres, and also the questions raised by its alleged connection with hardiness and by attempts to secure its elimination. J.A.F.R.

Live Stock; Inherited Defects of.

F. B. HADLEY and B. L. WARWICK. *J. Am. Vet. Med. Ass.*, Vol. 70, pp. 492-504, 1927.

This is a comprehensive review of the subject. Among those less known in this country are a defect of hair and teeth in cattle, and also defects due to arrested development of the Mullerian ducts. Cryptorchidism (i.e., the " rig " condition) seems to be inherited in other animals besides goats, as also entropion (i.e., invasion of the eyelids so that the lashes rub against the eye), which has been observed in lambs, dogs and horses, since it seems to occur with greater frequency in some breeds than in others. Among the hereditary defects of the horse which the authors cite are amaurosis or glass eye (wall eye?), cataract, bog spavin, melanosis (cancerous tumour), joint ill, roaring, periodic opthalmia (moon blindness), pulmonary emphysema (heaves), ring-bone, side-bone, roach back and undershot or overshot mouths.

Amongst cattle a new defect is described which has appeared in the Holstein Friesian. It is seen in new-born full term calves, and may be described as defective formation of the skin below the knees and hocks and the absence or incomplete development of one or more claws. The ears also are deformed, and there are defects in the muzzle, nostrils, tongue, hard palate and cheek. Forty-three such calves were obtained from thirteen herds. Thirteen of the calves were in one herd, where inbreeding had been practised to a considerable degree. The pedigrees of all calves were studied, and it was found that they all traced to the same foundation stock imported from Holland about 1871. A similar defect has been reported in Holland in herds carrying similar blood lines. The inheritance of this appears to be due to the action of a simple pair of recessive factors. The calves die in a few weeks from infection of the lesions. There are also notes of the inheritance of the ruptured condition in pigs. This is described in another abstract. A.D.B.S.

Mendelian Breeding with Wensleydale Sheep.

F. W. DRY. *J. Text. Inst.*, Vol. 18, pp. 415-420, 1927.

Some further results are given in connection with the well-known work of the writer on the inheritance of colour in Wensleydale sheep. In this breed black behaves as a simple recessive to white, but in

addition to this there is a well-marked modification of black into silver grey, the silver grey lambs being born with coats that are a mixture of black and of white fibres. The results up to the present are in harmony with the view that the silver grey character depends upon a single dominant modifying factor. J.A.F.R.

Milk Secretion; Studies in. Transmitting Qualities of Guernsey Sires for Milk Yield, Butterfat Percentage and Butterfat.

J. W. GOWEN. *Maine Sta. Bull.*, No. 329, p. 48, 1926.

In continuing this series, the 551 Guernsey sires having two or more tested daughters from tested dams, both with 365-day records, are tabulated, showing the net change in the age, corrected milk yield, and butterfat percentage, and the quartile change in the milk and butterfat production of the daughters as compared with their dams. The difference between the average production of the sire's daughter and their dams is considered as the transmitting quality of the sire. The probable errors of the difference between the milk and fat yield are tabulated for the entire population according to the number of daughters which a bull has. Special attention is called to the large probable errors in the case of bulls having few daughters. The bulls which raise the milk yield or butterfat percentage of their daughters as compared with their dams more than three times the probable error are tabulated, and available photographs of such animals were studied.

The large amount of variation observed in the conformation of both groups indicated that no incompatibility existed as far as conformation was concerned between milk production and butterfat percentage. Conformation as far as size is concerned has been found related to milk production, but neither the conformation of the daughter nor her parents has been found related to the fat percentage in the milk.

A.D.B.S.

Milk Yield and Butterfat Percentage in Ayrshire Cattle; Correlations between.

1. Individual Correlation.

G. BONNIER, *Hereditas*, Vol. 10, pp. 230-236, 1927.

It is known that milk yield and butterfat percentage are inherited though there is considerable ignorance as to the mode of inheritance. The writer, working with the results of seventy-nine cows of the Swedish Ayrshire breed, seeks to find out what, if any, is the correlation in one animal of these two points. He finds a quite definite correlation and affirms that the correlation co-efficient of any single cow between her yield and butterfat percentage is definite and heritable. He also postulates from his figures that there is some form of genetic linkage between the factors for the amount of butterfat and for correlation of yield of milk with butterfat percentage. There appears to be no correlation between yield of milk and the correlation of quantity of milk and butterfat percentage. A.D.B.S.

New-born Lambs; A Hereditary Lethal Deformity in.

J. A. F. ROBERTS. *J. Ministry Agr.*, Vol. 33, pp. 795-801, 1926.

A general account is given of a deformity of the limbs in new-born lambs. The affected lambs are born with the limbs in a state of complete rigidity. There is considerable hydramnios and in addition to the

inevitable death of the lamb, parturition is so difficult as frequently to cause the death of the mother also. The nature of the defect and its mode of occurrence are such that its existence in a flock might be easily overlooked unless a considerable number of affected lambs were born. The occurrence of the defect is unquestionably due to hereditary influences and probably it depends upon a single recessive factor.

J.A.F.R.

Offspring in Cattle; The Effect of Age of Parents on the Quality of.

A. C. CHAUDHURI. *J. Hered.*, Vol. 17, No. 10, pp. 368-370, 1926.

Using as data the prize-winners at the Highland Show in Scotland, and grading the parents according to the performance of their progeny in the Shorthorn classes, then classifying the parents into age groups, the writer finds no indication that the quality of offspring varied with the age of the parents. These results are confirmed by a comparison with the total number of cows calving at the different ages drawn from Vols. 58-70 of Coates' Herd Book for the period covering the time of the births of the dams of the prize-winning cattle.

An interesting sidelight is that the maximum number of prize-winning cattle belong to dams which calved at three or four years and are sired by bulls at the age of two years. A.D.B.S.

Pig; A case of Superfœtation in the.

A. D. B. SMITH. *J. Anat.*, Vol. 61, pp. 329-332, 1927.

A case is recorded of a Large Black sow which gave birth to a litter of four and a month later to a litter of ten. This is held to be a good example of true superfœtation, where the female already pregnant to one male is fertilised by another after an interval of time, the result being a mixed litter of different ages. J.A.F.R.

Pigs; The development and Maintenance of—during the Sucking Period.

J. SCHMIDT, E. LAUPRECHT, and H. VOGEL. *Zuchtungsk.*, Vol. 1, pp. 242-256, 1926.

The rate of growth and feed requirements were studied at the University of Göttingen from the records of six groups of pigs of different breeding obtained from various sources as follows: Forty-five litters of White Edelschwein at Ruhlsdorf, forty-eight litters of improved Landschwein at Ruhlsdorf, twenty-seven litters of improved Landschwein at Friedland, eight litters of Hanovarian-Brunswick Landschwein at Derneburg-Binder, six crossbred litters of Berkshire boars × improxed Landschwein sows at Friedland, and ten crossbred litters of Yorkshire boars × Hanovarian-Brunswick Landschwein sows at Binder.

The weights of the pigs at birth varied with the different groups, depending more especially on the mature weights of the breeds. Male pigs were somewhat heavier in nearly all groups than females. The weights and gains of the pigs at four weeks when supplementary feeding was started and at weaning time are given, together with the percentage gains during these intervals.

In the first four weeks the different groups increased from approximately 290 to 360 per cent. in live weight, and during the first eight weeks from 660 to 890 per cent. A classification into two groups according to the birth weights showed that the pigs with the heavier birth

weights made greater total gains to weaning, but the lighter pigs made considerably larger percentage increases over their birth weights. The same condition occurred in the comparison of the sexes.

The sex-ratio in 248 litters was 100·7 males to 100 females. The proportion of males was slightly less in litters of more than twelve pigs. Birth weights were found to be affected by litter size. In 168 litters of improved Landschwein the birth weights of individuals in litters of nine or more averaged 1·23 kg. (2·7 lb.) as compared with 1·37 kg. in litters of eight or less.

The amounts of sow's milk and feed consumed and the gains made per week are tabulated for the improved Landschwein and the crossbred Berkshire-Landschwein, including the feed necessary to produce a unit of gain up to weaning time. These results show that the crossbred pigs utilised their feed somewhat more economically than the purebreds.

A.D.B.S.

Sheep; An Achondroplasia-like Condition in the.

F. A. E. Crew. *Vet. J.*, Vol. 82, pp. 598-601, 1926.

A description of a "bull-dog" lamb. This case is very similar to the well known cases of bull-dog calves in cattle, but there are some differences, one being that in this case the limbs are not affected. The lamb was co-twin to a normal, so that there is strong evidence for a hereditary mechanism, as there is in the cases occurring in cattle.

J.A.F.R.

Swine Fever; Inheritance of Resistance to.

E. Roberts. *Proc. Amer. Soc. Anim. Prod.*, 1925-1926.

The Department of Animal Husbandry at the University of Illinois has bred from pigs which were obtained from a serum plant and had been found to be resistant to hog cholera. There is no doubt that resistance is hereditary. Owing to the expense of the investigation only comparatively few matings have been made, and it is not yet possible to describe the exact mode of the inheritance of this resistance. The economic importance of this work requires no comment. Some facts are also given concerning the natural resistance to bacillary white diarrhœa.

A.D.B.S.

PLANT PATHOLOGY.

Abstractor:

T. Whitehead, M.Sc., Ph.D., University College, Bangor.

Apple; Bitter Pit of. A Review of the Problem.

A. J. M. Smith, Dept. Scient. and Indust. Res. Food Invest. Board Special Report, 28, 1926. (Abstracted from *Rev. App. Mycol* VI, Pt. 3, 1927, p. 166).

This is a critical review of the several theories which have been put forward by workers on this obscure malady. The view that it is the result of local poisoning of the tissues is regarded as a possibility, but with no very strong evidence as yet in its support. Local desiccation theories are discounted and the author regards the drying out of the cells as the result and not the cause of death. The theory of cell rupture by root pressure is said to be based on the misconception that cells can be inflated with water by mechanical pressure, whereas a cell can only take in water until its osmotic pressure is balanced by the

tensions set up in the cell as a result of its elastic stretching. The theory of asphyxiation which is based on the similarity in appearance between bitter pit and certain forms of artificially produced brown heart is open to the objections that diurnal temperature fluctuations, which it was thought might result in a toxic concentration of carbon dioxide in the tissues of the apple at the lower night temperature, do not appear to play so great a part as varietal differences, the age of the tree, or even soil conditions, while the spread of bitter pit in storage is in marked contrast with the arrest of brown heart development.

Severe pruning and heavy irrigation towards the end of the season predispose to bitter pit, indicating that water relations are concerned in some way with the disease. In certain varieties bitter pit appears while the fruit is on the tree, in others it may develop rapidly after picking. There is, however, no definite information whether bitter pit invariably originates on the tree or whether sometimes it may develop *de novo* in storage. Orchard practices, which prevent bitter pit to some extent, may not actually control the cause of the disease but merely influence the susceptibility of the fruit. T.W.

Apple Scab Sprays; The timing of.

H. C. Young and C. May. *Ohio Agric. Exper. Stat. Bull.*, 403, 1927. (From Abst. *Rev. App. Mycol.*, VI, Pt. 9, p. 561, 1927).

Preliminary tests of sprays indicated that the state of the seasonal development of the trees was not a reliable indicator of the probable efficacy of the spray, as infection can take place readily at any time after the buds begin to open, depending only on the supply of ascorpores present in the orchard, sufficient air moisture, and a suitable temperature. Under Ohio conditions sprays were most effective when applied just previous to a rainy period. T.W.

Bordeaux Mixture; Chemical Hydrated Lime for the Preparation of.

E. B. Holland and G. M. Gilligan. *Phytopathology*, 17, 1927, p. 571.

The chief difficulty in the home preparation of bordeaux mixture lies in the proper slaking of the lime. This difficulty is removed by the commercial production of chemical hydrated lime from limestone. Laboratory determinations of the rate of deposit from suspensions of bordeaux made with nine different samples of chemical hydrated lime were regarded as satisfactory. The paper does not record any field trials with bordeaux made from chemical hydrated lime. (Abstractor's note:—The addresses of British firms supplying this substance can be obtained on application). T.W.

Carnation; Leaf-rot of. A new and dangerous disease.

E. S. Salmon and W. H. Ware. *Gard. Chron.*, LXXXI, 2,099, pp. 196 and 2,100, p. 216, 1927.

This new disease is caused by the fungus *Pseudodiscosia dianthi* and is characterised by a rotting of the leaves, usually near the base, at which point transverse cracks develop which cause the leaves to drop and shrivel. The whole plant may show a rusty brown appearance with a few green leaves projecting from amongst the curling, withered foliage. Sometimes the central shoot of unopened leaves may be pale and distorted as a result of an attack near its base. The bases of recently

attacked leaves have grey-brown, purple-zoned patches visible on both sides of the leaf, on which the fungal fruits form. For control of this disease the authors suggest careful selection of cuttings, rooted in sand, kept as dry as possible, and planted out in clean soil. Diseased plants should be removed and destroyed. Spraying or immersing plants in bordeaux mixture may be necessary to prevent infection. T.W.

Celery Blight, and its Prevention.

H. H. STIRRUP and J. W. EWAN. *Midland Agric. and Dairy College, Sutton Bonington, Loughborough, Report on above*, 1927.

Celery blight, or leaf-spot as it is known in its earlier stages, has been studied at Sutton Bonington for the last three years. The authors state that weather conditions greatly affect the seriousness of the damage done by this disease. During a dry spell of weather the disease receives a temporary check, but in wet weather the spread may be rapid. The most favourable conditions for the spread of blight are those in which the growth of the celery plant is slow (i.e., dry soil conditions), but in which on the other hand the disease spreads rapidly (i.e., moist conditions). These apparently mutually exclusive conditions are found during dry days followed by cool dewy nights.

Most outbreaks are said to be due to the use of infected seed, and the authors state that there is very little uninfected seed to be obtained in this country at the present time. After testing various fungicides such as formalin and hydrogen peroxide with a view to killing the disease spores on the seed, the conclusion was reached that, although some measure of success had been attained, seed sterilisation cannot be relied upon as an effective control of blight. On the other hand, by spraying the plants with either bordeaux mixture or burgundy mixture, the rapid spread of blight was to a large extent prevented. At least a month should be allowed after the last spraying before the plants are lifted for market. The authors give an interesting financial statement of the considerable profit accruing to one grower, as a direct result of spraying against blight. T.W.

Damping Off Fungi; Some chemical treatments of soil for the control of.

H. E. THOMAS. *Phytopathology*, 17, 1927, p. 499.

The fungi employed were two strains of *Phytophthora* isolated from tomato, and three strains of *Corticium vagum* isolated from cabbage, beet, and pepper. A known quantity of seed (usually 500) was sown in each bed, the soil being previously inoculated with one or other of the above " damping-off " fungi. In most cases the treatment with selected fungicides was made immediately after planting. The author states that, in preliminary trials, copper carbonate and Cheshunt compound gave similar and substantial increases in total and disease-free seedlings on soil inoculated with *Phytophthora*. In subsequent tests, copper carbonate was used alone or in comparison with mercury compounds, and occasionally with other chemicals. He concludes from his results that

1. Copper carbonate, mercuric chloride, and Uspulun controlled damping-off of tomatoes caused by *Phytophthora* spp.
2. The mercury compounds caused injury to tomatoes in concentrations which did not injure cabbage (i.e., 1-1600).

3. The mercury compounds were effective in controlling *Rhizoctonia* in cabbage and tomato plantings, whereas copper carbonate and two forms of colloidal copper were almost completely ineffective.
4. Treatments after damping-off had appeared were of little value to tomatoes or cabbage.
5. There was no evidence of chemical stimulation in any of these experiments. T.W.

Gooseberry (American Gooseberry Mildew); Further Experiments on the control of.

R. M. Nattrass. *Journ. Min. Agric.*, XXXIII, 11, p. 1,017, 1927.

The author has continued his experiments on the control of American gooseberry mildew. In a comparison of the efficiency of one application of burgundy mixture (8-20-100) as against one or two applications of ammonium poly-sulphide and soft soap (½ gall. A.P.S. and 5 lbs. soap in 100 galls. water) the burgundy sprayed plots gave 482 lbs. clean fruit and 4·3% mildewed, against 143½ lbs. clean and 39·9% mildewed fruit from the controls; the once and twice sprayed A.P.S. plots gave 456 lbs. and 502 lbs. clean fruit and 15·5% and 5·6% mildewed respectively. The burgundy sprayed plots showed a certain amount of spotting after ten days.

A second set of trials in which A.P.S. and soft soap (½ gall. A.P.S. and 6 lbs. soap in 100 galls. water) was used gave 169 lbs. clean fruit and 16·3% mildewed. Similarly, a proprietary soda sulphur compound and soft soap (10 pints and 6 lbs. respectively in 100 galls. water) gave 122 lbs. clean and 14% mildewed. Washing soda and soap (18 lbs. soda and 10 lbs. soap in 100 galls.) gave 95 lbs. clean and 30·1% mildewed. The control plots gave 66 lbs. clean and 58·7% mildewed. Whinham's Industry was used throughout and all were sprayed in both sets of trials on April 22nd, directly after the flowers had set; the second spraying, when applied, was carried out on May 18th. A second spraying was given with all the fungicides used in the second set of trials. The poor control obtained in the second set of trials was attributed to the shaded situation of the plots and to the fact that heavy rain affected the value of the second application of the fungicides. T.W.

Gooseberry (American Gooseberry Mildew); The control of, in Northern Ireland.

A. E. Muskett and E. Turner. *Journ. Min. Agric. for Northern Ireland*, Vol. I, 1927.

This is the record of four years work on comparing the value of a number of fungicides in controlling mildew. The author includes the following amongst his conclusions:—

1. A.G.M. can be satisfactorily controlled in N. Ireland by spraying.
2. Two sprayings with ammonium poly-sulphide have proved sufficient in these experiments. The first should be applied immediately after flowering and the second three weeks later; the first is of great importance and should not be delayed.
3. A.P.S. with soft soap has given the best results, closely followed by those obtained by using lime-sulphur with skimmed milk or flour paste as spreaders and sticking agents. Lime sulphur with lead arsenate and also ammonium poly-sulphide with lead arsenate sprays involve no risk of injury to

Whinham's Industry bushes if a little freshly slaked lime is added. By their use the damage done by the larvae of the Gooseberry Sawfly can be prevented by the same spraying. The lime sulphur-lead arsenate combination has proved to be of more fungicidal value than lime sulphur used with a spreader. A certain culmulative effect of spraying has been noticed in one badly infected plantation after five years spraying trials.

(4) Spraying appears to have no effect on the cropping of bushes, and experiments in a very young plantation have proved the control of mildew on rapidly growing bushes to be more difficult than on mature ones still making a fair amount of young growth.

(5) Washing soda (1 oz. per gall.) used with a spreader proved of little value in controlling the disease.

(6) Polysulphide sprays may be used on the varieties Whinham's Industry, Crown Bob, Whitesmith, Red Warrington, and Keepsake. Spray injury on Keepsake bushes has been occasionally recorded. "Amber" bushes and other sulphur varieties cannot be treated with polysulphides; one spraying with caustic soda (2%) in February followed by two with washing soda (1 oz. per gall.) in summer is recommended for these bushes.

(7) The cost of spraying for the most promising spray fluids used ranged from 4%–7½% of the crop value during the four years in which the trials were carried out. T.W.

Mangel Scab; Its Cause and Histogeny.

W. A. Millard and F. Beeley. *Ann. App. Biol.*, XIV, No. 3, 1927, p. 296.

Two types of scab are described—a raised type and a pitted form. The former type may be further subdivided into a mound and knob subtypes; the latter occuring more commonly on yellow skinned varieties.

From the mound type of scab a strain of *Actinomyces*, apparently a new species and here named *A. tumuli*, has been isolated and has reproduced the disease on inoculation. Similarly, an *Actinomyces* has been isolated from the pitted form and has reproduced the disease in inoculations. This proved to be *A. scabies*, and, in addition to attacking the "bulb" it reproduced numerous dark brown, nodular outgrowths on the true roots and fibrous rootlets of inoculated mangels. T.W.

Onion; The downy mildew of.

P. A. Murphy and R. M'Kay. *Sci. Proc. Royal Dublin Soc.*, N.S., XVIII, 17-28, p. 237, 1926.

The mycelium of *Peronospora schleideni* is not only able to perennate in the scale leaves of the bulbs but also in the stem or root stock. The negative results obtained by the authors in attempts to infect the bulb directly, together with their discovery that the bulb can be invaded by the fungus from the leaves, has led them to conclude that infection in nature occurs only through the leaves. There appears to be no danger of the disease spreading in storage.

The danger from autumn-sown seed, the seedlings from which become infected, is emphasised by the authors. Onion sets, potato-onions, shallots, onions grown for seed, Egyptian onions, and possibly

others may be carriers of disease and capable of originating disease in spring. No infection of seed has been demonstrated.

Up-to-date was the most resistant variety observed in 1922, followed in decreasing resistance by Stirling Exhibition, All-the-Year-Round, and an American variety, Wethersfield Red. In 1923 Ailsa Craig was most resistant but showed 20% of the plants killed by mildew.

Treatment of bulbs with dry heat showed that at 40C for eight, sixteen or twenty-four hours, or at 38C for sixteen hours were sufficient to kill all the fungus in the bulb without causing apparent injury to the bulb. T.W.

Parsnip Canker.

H. H. Stirrup and A. Roebuck. *Journ. Min. Agric.*, XXXIII, 9, p. 824, 1926.

This is a non-parasitic disease characterised by horizontal cracks in the root, at or near ground level. The skin is ruptured and an orange brown rot sets in, probably owing to the entry of fungi, and this eventually turns to a black soft rot destroying the whole root. The disease may be prevented by careful management of soil, tilth, and moisture to promote regular growth.

A search for resistant varieties is suggested and the authors state that in the season 1925-26 Large Guernsey and Tender and True varieties were only slightly affected, while Elcombe's Improved and Yates' Eversham were severely attacked. T.W.

Potato; Common Scab. The use of Sulphur as a control agent for.

G. H. Duff and C. G. Welch. *Phytopathology*, 17, No. 5, 1927, p. 297.

The authors report that sulphur was not uniformly effective in controlling scab under all conditions of soil and climate, but gave encouraging results only upon clay soils infested by moderate numbers or by attenuated strains of the organism and under conditions of light rainfall. T.W.

Tomata; Rhizoctonia "Foot Rot" of.

T. Small. *Ann. App. Biol. XIV*, No. 3, p. 290, 1927.

The disease caused by *Rhizoctonia solani* was least prevalent on dry open soils and most severe at temperatures ranging from 16C to 20C. The degree of infection was increased by stable manure; slightly decreased by ammonium sulphate; apparently unaffected by lime, potassic and phosphatic manures. Soil sterilisation by heat was the most effective and reliable means of controlling the disease. During the season the disease was checked by Uspulun. It is suggested that diseased plants and the soil immediately surrounding them should be removed with care, and the holes left should be treated with 0·25% solution of Uspulun. The areas can then be replanted and top dressed with ammonium sulphate. Weeds must be removed as they may serve as hosts and thus help in maintaining the virulence of the fungus.

T.W.

Leaflets; Ministry of Agriculture and Fisheries.

The following leaflets of interest to those concerned in the control of crop diseases have been recently issued, re-written or otherwise amended:—

No. 170. *The Use of Lime in Agriculture.* Revised, January, 1927.

No. 181. *The Culture of Green Peas and Beans.* Issued, May, 1927.
No. 188. *The Cultivation of Raspberries.* Issued, April, 1927.
No. 191. *Asparagus and its Cultivation.* Issued, June, 1927.
No. 193. *Dry Rot of Potatoes.* Amended, August, 1927.
No. 204. *Apple Mildew.* Revised, December, 1926.
No. 209. *Practical Soil Sterilization by Heat for Glasshouse Crops.* Issued, August, 1927.
No. 302. *The Silver Leaf Disease of Fruit Trees.* Re-written, September, 1927.
No. 346. *Gooseberries.* Revised, September, 1927.
No. 352. *The Control of Pests and Diseases of Fruit Trees in Gardens and Small Orchards.* Re-written, April, 1927. T.W.

SOILS AND MANURES.

Abstractor:

RICE WILLIAMS, M.SC., University College, Bangor.

Basic Slags; Some Experiments on.

E. VANSTONE. *Agric. Prog.*, 1927, 4, p. 92.

Investigations were carried out on the composition of basic slags by treatment with boiling ammonium chloride solution. Lime was brought into solution and the residues were much richer in phosphorus. It is concluded that the lime compounds in basic slag are readily decomposed, that in high soluble slags the phosphate is present as silico-phosphate and that in low soluble slags a basic tetra-calcium phosphate is present. The lime present in basic slags is regarded as a factor of great importance, as it is present in large quantity as di-calcium silicate and therefore an important source of available lime. R.W.

Calcium Silicates as a Source of Agricultural Lime; Synthetic. III. A comparison of the influence of synthetic calcium silicates with other forms of lime on soil reaction.

R. M. BARNETTE. *Soil Science*, 1926, 22, pp. 459-466.

Chemically equivalent and practical applications of calcium carbonate, hydrated lime, di-calcium silicate and limosil (a mixture of mono calcium silicate and calcium oxide) showed, within the limits of experimental error, an equal effect on the reaction of the soil as shown by hydrogen ion concentration. R.W.

Carriers of Phosphorus; The Relative Value of Different.

A. G. MCCALL. *Maryland Sta. Bull.*, 1926, 289, pp. 154-177.

It is concluded that under certain conditions raw rock phosphate can compete with acid phosphate as a carrier of phosphate, but that under most conditions, either when used alone or in combination with stable manure, the acid phosphate is the more economical source of phosphorus. Acid soil conditions seem to favour the raw rock phosphate. R.W.

Cyanamide; The Effect of Applications of—on the Nitrate Content of Field Soils.

F. E. ALLISON. *J. Agr. Research*, 1927, 34, pp. 657-672.

Cyanamide was found to retard nitrification in soil samples when taken from a field under cotton. This crop had a smaller supply of

available nitrate when fertilised with cyanamide than that on the control plot. Injurious decomposition products are believed to play a part in the unsatisfactory results, some of these injurious substances being direct plant poisons, whilst others only poison the nitrifying bacteria. R.W.

Farmyard Manure in Different Stages of Decomposition; Note on the Action of Hydrogen Peroxide on.

G. H. GETHIN JONES. *J. Agric. Sci.*, 1927, 17, p. 104.

The author has determined the degree of humification of farmyard manure by estimating the percentage decomposed with 6% hydrogen peroxide. It was found to depend on the amount of litter present, and the extent to which it was rotted, the best rotted samples showing about 74·5% humification. R.W.

Lime; The Effect of—on the Physical Properties of Soils.

Nebraska Sta. Rept., 1926, p. 15.

Lime did not appear to increase the moisture intake during wet periods, but showed a slight conservation effect during dry periods. Exposing soil treated with lime in cans out of doors resulted in the soil becoming more friable but showed no increase in pore space. The addition of lime with manure, and manure alone, caused a considerable increase in pore space and friability. Lime only slightly reduced the plough draught but considerably reduced the force required to shear or cut the soil. It did not alter the plastic properties of the soil but reduced its toughness when wet and its hardness when dry. R.W.

Marsh Soils; Fertilisers and Crops for.

A. R. WHITSON, A. R. ALBERT and O. R. LEASMAN. *Wisconsin Sta. Bull.*, 892, 1927.

Good drainage is regarded as of primary importance, and details of approved drainage practice are given. Potash is the common factor limiting crop yields and the equivalent of 75 lbs. per acre of muriate of potash for hay and grains and 100 lbs. per acre for potatoes, corn or root crops is recommended. Phosphate and lime is required on some of the marshlands dealt with. R.W.

Potash Content of Soil and Crop; The Effect of Lime and Fertilisers on.

J. G. LIPMAN, A. W. BLAIR, A. L. PRINCE. *Inter. Rev. Sci. and Pract. Agr.*, 1926, No. 8, pp. 546-558.

The results of studies conducted at the New Jersey Experiment Station, U.S.A., are reported in which the potash content of soils from a number of plots which had received definite fertiliser and lime treatment for a period of fifteen years were determined. It was also determined in several crops grown on the experimental plots. The percentage of potash in the soil of plots having parallel fertiliser treatment was slightly lower in nearly all cases for the limed than for the unlimed sections. Fertiliser treatment did not appear to have much influence on the potash content of the soil. There was a consistently lower percentage of potash in the cornstalks grown on the limed than on the unlimed sections. R.W.

Potash Salts; Effect of—on Crop Yields.

S. B. Haskell. *Massachusetts Expt. Sta. Bull.*, 232, 1927, pp. 44-51.

Long continued field tests carried out at the station are summarised. Potassic fertilisers when applied to a sandy loam soil and without supplementation by animal manures had a significant effect on crop yields, potatoes being very responsive while on clover-grass mixture a marked increase in the proportion of clover was shown. Equivalent quantities of sulphate and chloride of potash in general showed very little difference in their effects, but potatoes gave slightly greater increases with the sulphate. R.W.

Rate of Soil Liming; The Problem of.

J. A. Slipper. *Ind. Eng. Chem.*, 1927, 19, p. 561.

A study of seventeen liming experiments on a wide range of soils in the U.S.A. reveals that fractional rates of liming are more efficient per unit of lime than full applications. This was found to hold true for rotations that included such crops as corn, wheat, oats, clovers, barley, timothy, and lucerne. With all crops except one, lucerne, the first dressing of lime gave a relatively greater crop than did each additional dressing. Whilst lime additions are in arithmetic relationship, the crop relations are geometric. Coincident with this relationship is a similar one with reference to change in soil reaction by lime. The first increment of lime shifts the pH more than does each additional increment supplied in multiple additions. R.W.

Seaweed as a Manure.

F. Fumere Brin. *J. d'Agriculture Pratique*, 1926, 90, pp. 234-235.

A description is given of the collection and utilisation of seaweed by agriculturists of the Ile de Ré, France. The seaweed is put in heaps with alternate layers of farmyard manure and after several months of fermentation the compost formed is used for manuring winter barley. It also gives excellent results on early potatoes and is used as a foundation manure in conjunction with complementary minerals and fresh seaweed as a top dressing. R.W.

Soils and Fertilisers in 1926.

Sir E. J. Russell. *Agricultural Research in 1926*, pp. 134-167. Royal Agricultural Society, England.

A report is given of recent work on fertilisers and soils in different countries with special reference to certain American work. Fertilisers are considered under the following headings:—(1) New Fertilisers; (2) Phosphates and Potash; (3) Effectiveness of Fertilisers; (4) Field Experiments; (5) New Possibilities. Soils are considered as follows:—(1) Effect of Fertilisers on Soils; (2) Soil Constituents; (3) Soil Analysis; (4) Cultivation; (5) Soil Micro-Organisms. R.W.

SOILS AND FERTILISERS.

Ammoniacal and Nitric Fertilisers.

A. Demolon. *J. d'Agriculture Pratique, Paris.* 1927, 91, pp. 156-157.

When equivalent quantities of nitrogen are present nitrate of ammonia has been shown to be superior to sulphate of ammonia and the

nitrate of urea superior to urea alone. Trials on acid soils show that nitrate of soda gives better results than ammonical salts unless care is taken to add carbonate of lime to neutralise acidity when the latter are used. R.W.

Sulphate of Ammonia and Nitrate of Soda as Fertilisers; Summary of Experiment Station Field Plot Tests Comparing.

U.S. Dept. Agr., 1925, 38, p. 64.

The results of a large number of experiments conducted by various agricultural colleges and experiment stations and by the U.S. Dept. of Agr. comparing sulphate of ammonia and nitrate of soda as nitrogenous fertilisers are summarised. R.W.

Temperature near the Surface in Various Kinds of Soils.

N. K. JOHNSON and E. L. DAVIES. *Quart. J. Royal Meteorological Society*, 1927, 53, pp. 45-49.

Experiments were carried out on Salisbury Plain through year 1925 on six plots having the following surfaces:—(1) Tar-macadam; (2) Bare earth; (3) Grass; (4) Sand; (5) Rubble; (6) Bare Clay. The material constituting the surface was 15 cm. deep. Maximum and minimum thermometers were inserted in brass tubes 1 cm. in diameter and buried horizontally 1 cm. below surface. In addition a platinum resistance thermometer element was buried at a depth of 1 cm. below the surface and gave a continuous record of the temperature by means of a thread recorder. The following is a summary of the results:—(1) In summer the mean maxima are considerably higher than maximum air temperatures; (2) In mid-winter the mean soil maxima are all practically equal to that of the air; (3) The mean minimum soil temperatures throughout the year agree with the minimum air temperatures in the screen. The only exception being in the case of the grass covered soil in which the average minima are about 5°F. higher than the air minimum. R.W.

AGRICULTURAL BOOKS, 1926-27.

The following list, prepared by the staff of the National Library of Wales, is a selection of the more important books on the science and practice of Agriculture published during the period October, 1926 to December, 1927. The list supplements *The Hand-List of Books on Agriculture* issued by the National Library, *third edition*, 1926, copies of which can be obtained on application to the Librarian, The National Library of Wales, Aberystwyth.

ALLWOOD, Montague C.

Carnations for every garden and greenhouse.
London : Country Life, 1926.
pp. xvi, 140. col. front., ill. ... ... 12s. 6d.
A handbook for the beginner, the gardener and the commercial grower.

ATKINS, F. C.

Poultry farming without capital.
Newbury : The Author, 1927.
pp. 70 ... ... 1s. 0d.
A practical handbook for the one man business.

Modern egg farming. . . . *2nd ed.*
Newbury : The Author, [1927].
pp. 120. ill., fdg. diags. ... ... 2s. 6d.

BABCOCK, Ernest Brown, *and* CLAUSEN, Roy Elwood

Genetics in relation to agriculture.
2nd ed.
New York : McGraw-Hill Book Co., Inc., 1927.
pp. xiv, 674. col. front., ill., bibl. ... $5.00
A manual of theoretical and applied genetics.

BEAR, Firman E[dward]

Soil management. *2nd ed.*
New York : J. Wiley & Sons, 1927.
pp. viii, 412. ill., map, bibl. $3.50
Wiley Agricultural Series.
The planning of constructive systems of soil management. Assumes a knowledge of chemistry, botany, geology and physics.

Beckett, Edwin

Vegetables for home and exhibition. . .
London : Simpkin Marshall, 1927.
pp. [x]. 420. front. (port.), ill. ... 15s 0d.
Cultural methods and styles of exhibiting, with chapters on soil preparation, crop rotation, and pests and diseases.

Benton, Alva H.

An introduction to the marketing of farm products.
Chicago : A. W. Shaw & Co., 1926.
pp. xviii, 428. ill., maps, bibl. ... 20s. 0d.
Marketing under private enterprise and the producer's co-operative marketing system. The agencies described are mostly those of the U.S.A., and the concluding chapters are concerned with marketing legislation of that country.

Branson, J. B.

The perfect lawn : the preparation and maintenance of a lawn.
London : Fleetgate Publs., [1927].
pp. 80 ... ... 6d.

Brett, Walter

Bulbs and spring flowers.
London : Newnes, [1927].
pp. 64. front., ill. ... ... 1s. 0d.
The " How to Grow " Series.

The " how to do it " flower gardening book.
London : Pearson, 1927.
pp. 256. col. front., ill. ... ... 5s. 0d.

Rock plants.
London : Newnes, [1926].
pp. 64. front., ill. ... ... 1s. 0d.
The " How to Grow " Series.

British Government Publications. *Ministry of Agriculture and Fisheries.*

Research and the land : an account of recent progress in agricultural and horticultural science in the United Kingdom, by V. E. Wilkins.
London : H.M.S.O., 1926.
pp. xiv, 388. ill., pls., bibl. ... ... 2s. 6d.
Partly intended for the lay public, but chiefly intended to assist the farmer to understand how the results obtained in the laboratory can be absorbed into the ordinary practice of agriculture.

BROWN, E[dward] T[homas]

The " how to do it " poultry book.
London : Pearson, 1927.
pp. 256. col. front., ill. ... ... 5s. 0d.

A practical handbook for the man with a pen of fowls, and the commercial egg farmer.

A year in my flower garden.
London : Chapman & Hall, 1926.
pp. xii, 220. front., ill., pls. ... ... 7s. 6d.

The planning of the work in a garden for a whole year, commencing in November; written in the form of a diary.

BROWN, Harry Bates

Cotton : history, species, varieties, morphology, breeding, culture, diseases, marketing, and uses.
New York : McGraw-Hill Book Co., Inc., 1927.
pp. xii, 518. front., ill., bibl. $5.00
McGraw Hill Publications in the Agricultural and Botanical Sciences.

" The morphology, physiology, reproduction and heredity of the cotton plant; of cotton production; of cotton marketing, and of the products and uses of different parts of the cotton plant."

BRUCE, A[lexander] Bannerman, *and* HUNTER, H[erbert]

Crop and stock improvement.
London : Benn, 1926.
pp. 120. bibl. ... ... 5s. 0d.

The principles of heredity, as applied in the breeding of improved plants and animals.

BUECHEL, Frederick A.

The commerce of agriculture : a survey of agricultural resources.
New York : J. Wiley & Sons, 1926.
pp. x, 440. diags., maps. ... ... 18s. 6d.
The Wiley Agricultural Series.

A world survey of present-day agriculture. Discusses population in relation to agriculture; physical bases of production; world distribution; territorial specialisation.

CALTHROP, Dion Clayton

A diary of an eighteenth-century garden.
London : Williams & Norgate, [1926].
pp. viii, 128. col. front., ill., pls. ... 7s. 6d.

The diary of a man who loved his garden and noted many curious items of information about flowers, herbs, food and drink. The editor is a well-known novelist.

CANE, Percy S.

Modern gardens: British and foreign. . .
Special Winter Number of "The Studio" 1926-27.
London: The Studio Ltd., [1926].
pp. viii, 166. [pp. 25-166 ills.]. col. front., ill., pls.

Garden design from the artistic point of view.

CAVE, Herbert

Fertilisers, their sources, manufacture, and uses.
London: Pitman, [1926].
pp. xii, 116. front. (port.), ill. ... 8s. 0d.
Pitman's Common Commodities and Industries Ser.

A non-technical account of fertilisers, viewed chiefly from the commercial standpoint.

COMBER, Norman M[ederson]

An introduction to the scientific study of the soil.
London: Arnold, 1927.
pp. 192. ill., bibl. ... ... 7s. 6d.

A concise account, written by a teacher, for college students. Assumes the student has some general knowledge of physical and chemical science.

COOK, Lawrence J.

Carnation culture for amateurs. . . *5th ed.*
London: "Bazaar, Exchange & Mart", [1927].
pp. x, 86. front., pls., ill. ... ... 2s. 0d.

COTTER, *Sir* J[ames] L[awrence], *Bart.*

A simple guide to rock gardening.
London: Sheldon Press, 1926.
pp. 126. ... ... 2s. 6d.

COX, E[uan] H[illhouse] M[ethven]

The evolution of a garden.
London: Williams & Norgate, 1927.
pp. 256. bibl. ... ... 2s. 0d.
Home University Library of Modern Knowledge.

The modern English garden, its possibilities and limitations.

The modern English garden [Plates, with introductory letterpress].
London: Country Life, [1927].
pp. xxiv, 192 ... ... 21s. 0d.

Each illustration has been chosen for some detail in gardening, which can be adapted for other gardens.

COX, Joseph F., *and* STARR, George E.
Seed production and marketing.
New York : J. Wiley & Sons, 1927.
pp. xviii, 450. front., ill. $4.00
Wiley Farm Series.
Description of special cultural practices and equipment of the growers of various seed crops in the United States.

CRAN, Marion, *formerly* Dudley, *Mrs.* [George]
The gardens of good hope.
London : Jenkins, 1926.
pp. 326. front., pls. ... ... 10s. 6d.
Some gardens, public and private, of South Africa.

CROFTON, Helen, *formerly* Milman, *Mrs.* Caldwell
In the garden of peace : a paradise of birds.
[*3rd ed.*]
London : John Lane, 1926.
pp. xx, 182. ill. ... ... 6s. 0d.
Literary essays on gardens and life in a garden.

DARNELL, A. W.
Winter blossoms from the outdoor garden : a descriptive list of exotic trees, shrubs, and herbaceous plants that flower in the outdoor garden in the British Isles during . . . December, January, and February. . .
London : Reeve & Co., 1926.
pp. xxiv, 326. ill., pls. ... ... 21s. 0d.

DAVIS, Kary Cadmus
Farm projects and problems : a complete text for elementary schools.
Philadelphia : Lippincott, 1927.
pp. [xii], 540. front., ill. ... ... 7s. 6d.

DEVON CATTLE BREEDERS' SOCIETY, The
Devon Cattle : a work of reference officially compiled by the Devon Cattle Breeders' Society.
Reading : Philip Palmer Press, Ltd., 1927.
pp. 82. ill.

DUCANE, Florence
The flowers and gardens of Madeira.
(Reprinted with some slight alterations).
London : Black, 1926.
pp. viii, 150. col. front., col. pls.

Dumsday, William H.

Milk and dairies handbook. . . *4th ed.* of Madden's handbook of the law relating to dairies, cow sheds, and milk shops. . .

London : Hadden Best & Co., Ltd., 1927.

pp. xlviii, 264 ... ... 15s. 0d.

Part I. Milk and Dairies Acts and Orders.

Part II. Miscellaneous enactments affecting milk and dairies, with an Appendix consisting of Circulars and Orders issued by the Ministry of Health relating to milk and milk supplies.

Edminster, Lynn Ramsay

The cattle industry and the tariff.

New York : The Macmillan Co., 1926.

pp. xvi, 332. bibl. $2.50

One of a series of special investigations dealing with the relation of tariffs to particular products of the United States. The cattle industry has been chosen because of its economic importance. Gives a brief history of the trade in the United States and discusses the problems raised by competition and analyses the efficiency and expediency of duties on cattle and beef.

Fawcett, Howard S[amuel], *and* Lee, H. Atherton

Citrus diseases and their control, by H.S.F. . . with sections on oriental citrus diseases, by H. A. Lee.

New York : McGraw-Hill, 1926.

pp. xii, 582. ill., col. pls., bibl. $5.00

A comprehensive treatise on citrus diseases in all parts of the world. It treats of the identification and diagnosis of diseases and of control measures.

Gardner, W[illiam]

Fertilisers and soil improvers : description, application, and comparative value.

London : Crosby Lockwood, 1927.

pp. viii. 184 ... ... 7s. 6d.

Classification and description of the chief fertilisers and their values as plant food.

Garrad, G. H.

The principles of dairy-farming.

London : Benn, 1926.

pp. 200. bibl. ... ... 7s. 6d.

The Farmer and Stockbreeder Manuals.

The rearing, feeding, and breeding of dairy stock, with chapters on bacteria and the disposal of milk and milk

products. An attempt has been made to bring together the latest results of scientific investigation and research, indicating how the knowledge can be most practically applied.

GIBSON, J. L.

Carnations for amateurs : (a practical and modern guide to carnation growing).
London : Collingridge, [1926].
pp. 128, [ii]. col. front., ill., pls. ... 5s. 0d.

COBLET D'AVIELLA, Felix

Histoire des bois et forêts de Belgique.
Paris : Paul Lechevalier, 1927.
3 vols. pls., maps, bibl. ... 128.75 fr.

A geological, botanical and economical study of Belgian forests and their extent, from prehistoric times to the end of the Austrian régime. Shows the influence of forests on the social and economic life of the inhabitants.

HALSHAM, John

Every man his own gardener.
London : Hodder & Stoughton, [1927].
pp. xii, 288. front., ill. ... ... 6s. 0d.

Primarily designed for those with little or no experience of gardening, and restricted to out-door cultivation of vegetables, flowers, and fruit.

Every man's book of garden flowers : with short directions for their culture.
London : Hodder & Stoughton, [1927].
pp. 374. front., ill. ... ... 6s. 0d.

HEALD, Frederick DeForest

Manual of plant diseases.
New York : McGraw-Hill Book Co., Inc., 1926.
pp. xiv, 892. ill., bibl. $7.00
McGraw-Hill Publications in the Agricultural and Botanical Sciences.

A college textbook in general plant pathology, including environmental and virus diseases as well as those of bacterial and fungous origin. Deals with types of diseases rather than the detailed treatment of individual diseases.

HENSLOW, T[homas] Geoffrey W[all]

Garden architecture.
London : Dean, 1926.
pp. x, 240, lx. front. (port.), ill. ... 10s. 0d.

How to design and construct gardens of various kinds.

HENSLOW, T[homas] Geoffrey W[all]

Garden renovation.

London : Dean, 1926.

pp. xxii, 416, xxiii-cxl. col. front., pls., plans ... ... 15s. 0d.

Primarily intended as a guide for the remodelling of old estates, large and small, from the garden standpoint, especially as regards plants, trees, and shrubs.

HOUSE, C[harles] A[rthur]

Laying hens, their selection and breeding.

London : The Poultry Press Ltd., [1927].

pp. 98. ill., pls. ... ... 2s. 0d.

ISHERWOOD, R[obert]

Notes on infectious diseases of animals.

Warrington : Baldry & Lythgoe, 1926.

pp. viii, 104. bibl. ... ... 4s. 6d.

A small handbook on microbial diseases.

JEKYLL, Gertrude, *and* HUSSEY, Christopher

Garden ornament. . . (*2nd ed.*).

London : Country Life, 1927.

pp. x, 438. front., ill. ... ... 63s. 0d.

Photographs, which have appeared in *Country Life*, of garden ornamentation, from which ideas and patterns can be derived. Each form of garden is accompanied by a short historical sketch, and shows the garden design in relation to the architecture of the house.

JENKINS, Anna E.

Brown canker of the rose. . .

Excerpt . . . from the 1927 *American Rose Annual.*

West Grove, Pa., The American Rose Soc., 1927.

pp. 161-188. pls.

Most of the field observations have been made on rose-plantings maintained at the Arlington Rose Test-Garden, Washington, D.C.

JOAD, Doreen

Gardening in town and suburb.

London : Labour Publ. Co., Ltd., 1927.

pp. 96. plan. ... ... 2s. 6d.

A guide for the small garden, cultivated under town conditions, and restricted to back yards, roofs, balconies and window boxes.

JOHNSON, A[rthur] T[ysilio]

A garden in Wales.

London : Arnold, 1927.

pp. xii, 324. front., pls. ... ... 16s. 0d.

A book of conversational description with practical advice. The area is typical of considerable tracts, not only of Wales, but of the western counties of England.

JONES, Hugh

Modern Denmark : its social, economic, and agricultural life.

London : King, 1927.

pp. xii, 84. bibl. ... ... 2s. 6d.

A comparison of the rural problems of England and Wales, and Denmark.

KAUPP, B[enjamin] F[ranklyn].

Poultry diseases, including diseases of other domesticated birds ; with a chapter on the anatomy of the fowl. *4th ed. rev. and enl.*

London : Baillière, Tindall & Cox, 1927.

pp. 394. ill. ... ... 15s. 0d.

Sanitation, hygiene, disinfection, and causes of disease. The effects of feeding upon the health of birds and on their growth and production.

KELLNER, O.

The scientific feeding of animals, by O.K. . . trans. by W. Goodwin. . . (*2nd ed. rev.*).

London : Duckworth, 1926.

pp. xiv, 328 ... ... 8s. 6d.

The main principles of the theory of feeding and a short descriptive account of different feeding stuffs.

KING, Franklin Hiram

Farmers of forty centuries; or, permanent agriculture in China, Korea, and Japan.

London : Cape, 1927.

pp. 380. ill. ... ... 12s. 6d.

An account of the agricultural methods in use to-day in China, Korea and Japan, showing how agricultural methods of modern countries can be improved by the experience gained in forty centuries in the Far East.

KING, Louisa Yeomans, *Mrs.* Francis

The beginner's garden.

New York : Scribner, 1927.

pp. xii, 126. front., pls., ill., fdg. plans. 7s. 6d.

Planning a garden in relation to the house. Whilst written for the beginner, the suggestions as to garden-planting, especially the detailed plans, are of use and value to the more experienced gardener.

LAMBERT, Norman, *and* THOMAS, H[enry] H[iggott]

Sweet peas for amateurs.
London : Cassell, 1927.
pp. viii, 184. front., ill., pls. ... ... 2s. 6d.

LAND AND NATION LEAGUE, The

The farmer and his market : a report by the Land and Nation League.
London : Benn, 1927.
pp. vi, 116 ... ... 1s. 0d.

Advocates a national policy for agricultural marketing.

LARMER, Forrest M.

Financing the livestock industry.
New York : The Macmillan Co., 1926.
pp. xvi, 328 ... ... $2.50

A discussion of the American live-stock problem.

LAW, Ernest

Hampton Court gardens : old and new ; a survey, historical, descriptive and horticultural. . .
London : Bell, 1926.
pp. 80. front., pls., ill., plans ... ... 3s. 6d.

A guide to Hampton Court gardens, including the lay-out, with tabular lists of the flowers.

LEAKE, H[ugh] Martin

Land tenure and agricultural production in the tropics. (Being a discussion on the influence of the land policy on development in countries).
Cambridge : Heffer, 1927.
pp. x, 140. front. ... ... 7s. 6d.

Land tenure in relation to the general problems of agricultural development in the countries which come within the British sphere of influence.

LINTON, R[obert] G[eorge]

Animal nutrition and veterinary dietetics.
Edinburgh : Green, 1927.
pp. xii, 400. front., pls., ill. ... ... 2s. 0d.
Edinburgh Veterinary Series.

Explains how animals, kept under modern farming and commercial conditions, may be fed economically. Chapters on the composition and functions of foods in general and on grains and seeds in particular, their nutritive value and preparation and storage, etc.

Livingston, Alfred E.

The management of greenhouses and frames.
London : Crosby Lockwood, 1927.
pp. [viii], 128. ill. ... ... 2s. 6d.

Mace, Herbert

Modern bee-keeping.
Harlow, Essex : The Author, 1927.
pp. 226, xx. ill. ... ... 5s. 0d.

General management, rearing and diseases of bees, with full instructions for the beginner and advanced methods for the expert. Contains, as a supplement, a list of beekeepers' associations and guide to supplies.

Macself, A. J.

The fruit garden.
London : Butterworth, 1926.
pp. 222. ill., pls. ... ... 6s. 0d.
The Home Garden Books.

How to produce more and better fruit.

Vegetable gardening.
London : Thornton Butterworth, 1927.
pp. 240. col. front., ill. ... ... 6s. 0d.
The Home Garden Books.

Construction, equipment and general management of the vegetable garden, with chapters on some staple food crops.

Millais, J[ohn] G[uille]

Magnolias.
London : Longmans, 1927.
pp. viii, 252. front., pls. ... ... 32s. 0d.

A history and description of the magnolias. Gives an account of all the species and various hybrids, with a key.

Morland, George

My farm in miniature.
London : Faber & Gwyer, 1927.
pp. 288. ill. ... ... 10s. 6d.

Written primarily for the owner of from three to five acres, and deals with every aspect of farming, including book-keeping for the small farmer.

Morrison, Robert

The individuality of the pig : its breeding, feeding, and management.
London : Murray, 1926.
pp. xii, 378. ill. ... ... 7s. 6d.

The life of the pig from birth : housing, rearing, feeding, selling, killing, and showing. A practical manual.

Norris, William J. Caton

Life and work on the land : practical notes on agriculture, livestock, pastures, estate repairs, bungalow building, etc.
Northampton : W. Mark & Co., Ltd., 1926.
pp. 128. ... ... 3s. 6d.

Notcutt, R[oger] C[rompton]

A handbook of flowering trees and shrubs.
London : Martin Hopkinson, 1926.
pp. [xii], 246. front., pls. ... ... 12s. 6d.

A description of the better known families of the hardy flowering shrubs, for the use of the amateur gardener.

Oxford, *University. Agricultural Economics Research Institute.*

Economics of production of grade " A " (tuberculin-tested) milk, by V. Liversage.
Oxford : The Clarendon Press, 1926.
p. 58. ... ... 2s. 0d.

The rural industries of England and Wales : a survey made on behalf of the Agricultural Economics Research Institute, Oxford.
Oxford : Clarendon Press, 1926-27.
4 vols. 5s. 0d. each volume.

[Vol.] I. Timber and Underwood Industries. . . by H. E. FitzRandolph and M. D. Hay.
pp. xvi, 240. front., pls.

[Vol.] II. Osier-growing and basketry. . . by H. E. FitzRandolph and M. D. Hay.
pp. xii, 160. front., pls.

[Vol.] III. Decorative crafts and rural potteries, by H. E. FitzRandolph and M. D. Hay.
pp. xii, 168. front., pls.

[Vol.] IV. Wales, by A. M. Jones.
pp. xii, 124. front., pls.

A study of the present state and functions of local industries in rural life, and how they can be utilised to supplement agricultural pursuits. The survey was carried out during three years and the country was dealt with county by county.

Penlington, W. A. G.

Science of dairying : a text book for the use of secondary and technical schools. . .
(*2nd ed.*)
London : Macmillan, 1927.
pp. viii, 274. ill. ... ... 3s. 0d.

PEROLD, A. I.

A treatise on viticulture.
London : Macmillan, 1927.
pp. xii, 696. ill., pls, bibl. ... ... 25s. 0d.

A textbook for the student and practical grape grower. Deals with the biology of the vine, its external and internal morphology and the theory of grafting and, on the practical side, with the propagation, manuring and pruning of the vine and the production of table grapes for export.

PIETERS, Adrian J[ohn]

Green manuring : principles and practice.
New York : J. Wiley & Sons, 1927.
pp. xiv, 356. ill., bibl. $4.50
Wiley Agricultural Series.

A short history of green manuring, followed by a discussion on the organic matter in soils, its source and the influences which operate upon it. An analysis of the composition of green manure plants and its use in the United States and other countries.

PORTER, John

The stockfeeder's companion. . .*2nd ed. rev and enl.*
London : Gurney & Jackson, 1927.
pp. xxiv, 364. ill., pls. ... ... 7s. 6d.

An attempt to write, in simple language, a textbook for farmers and students on foods and feedings. Nearly all the feeding trials referred to are English. Discusses the relation between animals and plants; available foods and their composition and the feeding of various classes of animals, with an appendix of experiments and feeding trials.

POULTRY Club, The

The poultry club standards. . .ed. by W. W. Broomhead, *7th ed.*
London : The Club, 1926.
pp. xii, 156. front. ... ... 8s. 0d.

Descriptions of the recognised breeds and varieties of fowls, bantams, ducks, geese and turkeys.

PREWETT, F. J.

The marketing of farm produce. Pt. II Milk.
Oxford : The Clarendon Press, 1927.
pp. viii, 84. maps, diags. ... ... 8s. 6d.

Vol. I, published in 1926, dealt with Live Stock.

Protheroe, Rowland E[dmund], *Baron Ernle.*
English farming, past and present. . .*4th ed.*
London : Longmans, 1927.
pp. xvi, 506. bibl. ... ... 12s. 6d.

A history of English agriculture, tracing the influence of the progress of the industry on the social conditions of those engaged in its pursuit.

Recknagel, A[rthur] B[ernard], *and others.*
Forest management, by A. B. R., J. Bentley, and C. H. Guise. . .*2nd ed.* . .*rev.*
New York : Wiley, 1926.
pp. xviii, 330. front., diags. $3.50

Textbook on forest mensuration, organisation, and finance. The subject is treated along lines of American practice.

Reeks, H. Caulton
The common colics of the horse : their causes, symptoms, diagnosis and treatment. *4th ed.*
London : Baillière, Tindall & Cox, 1927 (1926).
pp. xviii, 404. ill. ... ... 10s. 6d.

Rew, *Sir* R[obert] Henry
A primer of agricultural economics.
London : Murray, 1927.
pp. 280. bibl. ... ... 5s. 0d.

Factors and cost of production and the disposal of produce.

Robinson, William
The English flower garden and home grounds of hardy trees and flowers only. *14th ed. rev.*
London : Murray, 1926.
pp. xii, 710. ill. ... ... 24s. 0d.

In two parts, the second and larger being a list in alphabetical order of the flowers, trees, flowering shrubs, evergreens and hardy ferns for the open flower garden in the British Isles.

Rohde, Eleanour Sinclair
Garden-craft in the Bible, and other essays.
London : Jenkins, 1927.
pp. 242. front., pls. ... ... 10s. 6d.

Essays on famous gardens, ancient and modern.

A garden of herbs. . .*rev and enl. ed.*
London : Jenkins, 1926.
pp. xvi, 300. front., pls., bibl ... 10s. 6d.

A practical handbook on the construction of a herb garden. A few recipes included.

ROYAL Horticultural Society, The
The pruning of hardy fruit trees, by C. R. Fielder. *3rd ed.*
London : The Society, 1926.
pp. 16. ill. ... ... 6d.
One of a series of pamphlets published by the Royal Horticultural Society on gardening subjects.

RUSSELL, *Sir* Edward John
Soil conditions and plant growth. . .*5th ed.*
London : Longmans, 1927.
pp. viii, 516. front. (port.), pls., ill., bibl. 18s. 0d.
A new edition of this important work, embodying the results of recent investigations and experiments in the chemistry, microbiology and physics of soil.

SANDERS, *Royal Orchid Nurseries, St. Albans.*
Sanders' orchid guide : *rev (1927) ed.*
Belgium pr. Publ. by Sanders, St. Albans, 1927.
pp. [vi], 452. front. (port.) ... ... 31s. 6d.
An alphabetical list of orchids, with brief descriptions and cultural notes.

Second addenda to Sanders' orchid hybrids. 1924-1925-1926.
Antwerp : pr. by C. G. Kohler, [1927].
pp. 52.

SCOTT, George R.
The truth about poultry : an exposure of humbug.
London : The Poultry Press Ltd., [1927].
pp. x, 158. front. (port.) ... ... 5s. 0d.

SCOTT, J[ohn] W. Robertson
The dying peasant and the future of his sons.
London : Williams & Norgate, 1926.
pp. xvi, 282. ... ... 10s. 6d.
Mainly concerned with the agricultural worker, the conditions of labour, housing and wages, etc.

SEEBOHM, *formerly* Christie, Mabel Elizabeth, *Mrs.*
The evolution of the English farm.
London : Allen & Unwin, 1927.
pp. 376. front., pls., ill., bibl. ... ... 16s. 0d.
Shows the gradual growth of the English farm, from the Stone Age to modern times. Farmhouse, outbuildings, stock, implements, orchard and garden, the duties of those who live on the farm, are all touched upon. Chapter III gives an account of the development of the Celtic farm in the Iron Age.

SESSIONS, William H.

The selling side of agriculture.

London : Simpkin, Marshall, 1926.

pp. 70. maps. ... ... 2s. 0d.

Advocates the elimination of the middleman, and co-operative selling as aids to the improvement of the agricultural industries.

SETON, F[rances] E[veleen], *Lady.*

My town garden.

London : Nisbet, 1927.

pp. 224. front., ill., pls. ... ... 6s. 0d.

How to make and keep a small town garden, with descriptive lists of suitable plants.

SHEPPERD, J[ohn] C[hiene], *and* JELLICOE, G[eoffrey] A[lan]

Gardens and design.

London : Benn, 1927.

pp. 248. ill., plans, bibl. ... ... 63s. 0d.

The fundamental principles of garden architecture, English and foreign, with many notes of the social life and ideals of the times when the various styles were designed or developed.

SKENE, Macgregor

Trees.

London : Williams & Norgate, [1927].

pp. 256. bibl. ... ... 2s. 0d.

Home University Library of Modern Knowledge, Vol. 126.

A brief history and description of trees generally, with a chapter on the trees of Britain.

SMITH, William W.

The elements of live stock judging.

Philadelphia : Lippincott, 1927.

pp. viii, 148. ill. ... ... 10s. 6d.

STAPLEDON, R[eginald] G[eorge] *and* HANLEY, J. A.

Grass land, its management and improvement.

Oxford : Clarendon Press, 1927.

pp. 160. bibl. ... ... 5s. 0d.

STEP, Edward

Summer flowers of the wild.

London : Jarrolds, Ltd., [1927].

pp. xii, 192. front., ills. ... ... 5s. 0d.

A book for the nature-lover and rambler, giving brief lives of summer flowers, and their relations to insects, animals, and other plants. A continuation of *Spring flowers of the wild.*

STEWART, George

Alfalfa growing in the United States and Canada.
New York : The Macmillan Co., 1926.
pp. xxiv, 518. front., ill., bibl. ... 15s. 0d.

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